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THE RELATION OF THE PRESENTING SYMPTOMS TO THE SELECTION OF THE METHOD OF TREATMENT IN UTERINE MYOMA*

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THE methods of treatment of uterine myomas causing symptoms are medical, surgical and radiological. The mode of selection of the indicated form of treatment for a given case appears to vary among the clinicians as may be seen from a perusal of the literature and the discussions in medical societies. Obviously such discrepancies in the selection of the form of treatment should not prevail. It is evident that each method of treatment should have clear-cut indications so that the patient may receive the form of treatment adapted to the condition.

A study of the clinical aspects of uterine myomas has been made. It was found that a definite relation existed between the presenting symptoms and the presenting physiological and anatomical, i.e., functional and structural pathology and that the selection of the form of treatment may be based on such clinical studies. Thus a uniformity in the selection of the indicated form of treatment would be attained.

CLINICAL ASPECTS OF UTERINE MYOMA

A uterine myoma may not cause any symptoms or may cause either menorrhagia, metrorrhagia, pain or a combination of these symptoms.

The menorrhagia or hypermenorrhea may result (*a*) from disturbances of endocrine functions, such as hypersecretion of prolan A and estrin, hyposecretion of prolan B and progestin, and rarely hypofunction of the thyroid gland or hyperfunction of the adrenal cortex; (*b*) from the loss of contractility of the myometrium due to hypoplasia, atony and intramural and sessile submucous myomata.

The functional disturbances may occur at all ages but are most frequently observed at the beginning of menstrual life when ovarian and uterine functions are started and at the termination of menstrual life when these functions begin to ebb. The anatomical disturbances such as hypoplasia and atony may be congenital while atony and myoma may be acquired. The anatomical disturbances may cause symptoms at all ages, but singularly are most frequent during the climacteric when an ebbing of the reproductive processes takes place. Intramural and sessile submucous myomas obviously interfere with the normal contractility of the myometrium and thus cause prolonged and profuse menstruation.

Metrorrhagia is caused by (*a*) loss of surface continuity of the uterine or cervical mucosa as observed in hemorrhagic metropathy due to persistent graafian follicle,

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ulceration, carcinoma, or sarcoma; (*b*) pedunculation of a submucous myoma which plays the part of an intracorporal foreign body. These anatomical changes may occur at any age but, as a rule, appear most frequently during the fourth and fifth decades of life, i.e., the menopause; (*c*) complications in the myomas, such as degenerations, axial rotation of pedunculated tumors and the myomatous uterus or strangulation of the peduncle of pedunculated tumors. These accidents cause symptoms which have been designated as the "acute abdomen."

Pain is either a pressure pain from limitation of space and weight of a large myoma, or inflammatory pain from degeneration of the myoma, endogenous or exogenous infections and torsions of pedunculated myomas.

Pressure pain from limitation of space is associated with myomata incarcerated within the true pelvis. The loss of mobility is caused by pelvic adhesions and intraligamentary, subperitoneal or cervical development. The tumor cannot rise out of the pelvis and as soon as it fills the true pelvic cavity pressure is exerted on the urinary canal, the terminal bowels, the pelvic blood vessels and nerves. The most frequent of the pressure symptoms is the urinary with dysuria, polyuria and ischuria. These disturbances are constant and become progressively worse with the increase in the size of the growth. Large myomata that have escaped into the abdominal cavity cause distress from the bulk and weight of the growth. Structures at the brim of the pelvis are pressed upon when the patient is in the upright position. The pressure is relieved in the prone position. Large myomas may press upon the diaphragm causing embarrassment of heart and lung action in the prone position and relief in the upright or semiprone position.

Sterility and accidents of pregnancy and labor are at times the result of uterine myomas. It is, of course, necessary to determine the pH of the vaginal secretion, the basal metabolism rate, the Huhner test, and the patency of the uterine tubes before stating the myoma to be the cause of the disturbance of the reproductive functions.

Inflammatory pain accompanies torsion of pedunculated myomas, degenerative processes, complications within the tumor such as ruptured blood vessels or true infections either from without or within. It is difficult to diagnose the kind of degeneration, strangulation or infection. Hence the onset of sarcoma in a myoma cannot be differentiated from benign degenerations, and infections cannot be differentiated from axial rotations and subsequent necrobiosis. As inflammatory pain and pain from degenerative changes constitute a surgical abdomen, the positive diagnosis can be made during operation.

It is obvious that bleeding, either menorrhagia or metrorrhagia, may be associated with pain either from pressure or inflammation and degeneration.

A summary of the clinical aspects would be as follows:

1. Menorrhagia is found with endocrine disturbances, atony or hypoplasia of uterus and intramural and sessile submucous myomas.

2. Metrorrhagia results from loss of continuity of surface epithelium such as pressure atrophy, ulceration, carcinoma, sarcoma and pedunculated intracorporeal myoma, and degenerative processes.

3. (*a*) Pressure pain follows incarceration of a myoma in the true pelvic cavity and pressure from large myomas within the abdominal cavity; (*b*) inflammatory pain is due to endogenous or exogenous infections, degenerations, torsion of pedunculated myomas and axial rotation of the uterus with a myoma.

4. One may therefore speak of menorrhagic, metrorrhagic and painful myomas. There must be a necessary connection between cause and effect, and the symptoms represent specific disturbances or characteristics of growth. It thus seems that the presenting symptom may be a fine indicator for the selection of the method of treatment.

SELECTION OF THE METHOD OF TREATMENT

The treatment of uterine myomas is conservative or causal. Conservative treatment consists in observation or follow-up of the silent myoma and in medical management of those myomas resulting from or causing a functional derangement. Causal treatment is radiological or surgical. Irradiation arrests ovulation and hence also profuse or prolonged menstruations, but leaves the growth undisturbed. It arrests a physiological process. Surgery removes the growth, and often the uterus. It is an anatomical treatment. The ideal treatment would be the removal of the myoma and the preservation of all the genital organs with complete maintenance of the function of reproduction and with the smallest risk to the patient. The desire of a patient to retain complete sex functions or to have offspring should always be heeded. The only form of treatment which attains this end is myomectomy. Medical and radiation treatment render the tumor symptomless. The absorption or regression following irradiation is an indirect result and may be seen in about two-thirds of such cases.

Conservative or medical management is given to correct the dysfunction caused by or accompanying the myoma. Thus uterine atrophy and asthenia are corrected by regulation of diet and exercise and the use of medicinal agents that will reëstablish tonicity and normal contractility of the myometrium as hydrastis and ergot. Endocrine disturbances require replacement therapy. The under- or overactivity of the endocrine glands should be balanced. This is at times a difficult undertaking. If medical management does not arrest the profuse and prolonged menstrual flow then curettage is employed which arrests the hypermenorrhea permanently in about one-third of such cases. The treatment as outlined assures the most ideal results in the young and mature woman in whom gestational functions should be preserved if at all possible. Curettage is the best hemostatic, it stimulates tonicity of the uterus and frequently ovarian function.

The necessity of conserving reproductive functions calls attention to the importance of age in the treatment of myoma. The treatment should be conservative in the young and mature, but may be causal in the menopause and senile age groups. The age periods are: up to twenty years, the juvenile; from twenty-one to forty years, the mature; from forty-one to the cessation of menstruation, about the fifty-fifth year, the menopausal; and after fifty-five years, the senile.

In the menorrhagic myomas conservative treatment should be carried out if at all possible in the juvenile and mature periods; radiation therapy in the menopausal period, and surgery in the senile period. Should the menorrhagia accompany an intramural, submucous or pedunculated fibroid and not respond to conservative treatment, then myomectomy, either vaginal or abdominal, is advised. Radiation therapy is indicated in the uterine myoma causing menorrhagia in the menopausal period and vaginal or abdominal hysterectomy in the senile period. Radium may be used in the small intramural or sessile submucous myomas in a uterus not exceeding the size of a twelve week pregnancy, while roentgen therapy may be employed in uteri up to the size of a six months pregnancy.

The metrorrhagic and painful myomas indicate surgery. The former occur usually in the senile age period, while the painful myomas may occur at all ages and demand surgical intervention. Myomectomy should be performed during the juvenile and mature age groups, hysterectomy during the menopausal or senile age groups. Should contraindications to surgery exist, then irradiation may be given in the hope of rendering the patient free from symptoms. Sarcomatous degeneration in the myomas and complicating malignancy such as endometrial carcinoma or sarcoma respond well to adequate radiation dosage. In my experience an absolute 30 to 35 per cent five-year cure was obtained.

The indications for the various forms of treatment may be summarized as follows:

The menorrhagic myomas during the juvenile and mature age groups indicate conservative treatment, either correction of endocrine dysfunction or treatment for the hypoplastic, atonic myomatous uterus. If these fail, curettage and finally myomectomy should be considered. The menorrhagic myoma during the menopause is best treated by irradiation, and during senility with hysterectomy. The metrorrhagic myoma indicates surgical treatment at all times as it may be impossible to rule out malignancy in the degenerating myoma or a complicating malignancy with the myoma. The painful myoma also indicates surgery as the inflammatory or degenerative changes can be diagnosed only with difficulty by any other method than exploratory laparotomy.

RESULTS OF TREATMENT

The results of treatment according to these indications were studied in 263 consecutive cases of uterine myomas. Table I shows the form of treatment used in these cases.

TABLE I

Form of Treatment	Number	Per Cent
Observation	19	7.23
Conservative	17	6.46
Surgical	114	43.37
Radiological	113	42.94
Total	263	

The methods of surgery according to age groups are recorded in Table II.

TABLE II

Method of Surgery	Age Group				
	Up to 20	21 to 40	41 to 55	56 plus	Total
ABDOMINAL					
Myomectomy		18	7		25
Corpus amputation		44	23	1	68
Hysterectomy		2	6		8
Panhysterectomy		5	4		9
VAGINAL					
Myomectomy		6	2	1	9
Hysterectomy		3	2	1	6
		78	44	3	125

TABLE III

Method of Surgery	Number	Recovered	Unimproved	Malignancy	Mortality
ABDOMINAL					
Myomectomy	25	23	2		
Corpus amputation	68	68			
Hysterectomy	8	8		1	
Panhysterectomy	9	8			1
VAGINAL					
Myomectomy	9	6	3	1	
Hysterectomy	6	5			1
	125	118 or 94.4%	5 or 4.4%	2 or 1.6%	2 or 1.6%

Table IV

Kind of rays	Up to 20	21 to 40	41 to 55	56 plus	Total
RADIUM Mg-el-hr.					
600	2	1	2		5
900		1	1		2
1200		19	28	1	48
1800		2	3		5
2400		9	14		23
					83
ROENTGEN r					
Permanent 300	3	11	8		22
Temporary 225	1				1
					23
ROENTGEN RAYS AND RADIUM					
1500 r+1200		4	2	1	7
1500 r+1800			1		1
1500 r+2400			6	1	7
					15
	6	47	65	3	121

The end-results of surgical treatment are seen in Table III.

The form of radiation treatment and the doses used in the different age groups are seen in Table IV.

The results and complications of radiation therapy are enumerated in Table V.

The comparison of the results of surgical and radiation treatment in uterine myomas is shown in Table VI.

Table V

Radiation	Number	Unimproved	Subsequent Surgery	Uterine Malignancy	Mortality	Recurrence of Normal Menses	Repetition of Treatment
Radium	83	9, or 10.8%	8, or 9.04%		0	8, or 9.04%	4, or 4.5%
Roentgen rays	23	1, or 4.35%	1, or 4.35%	1, or 4.35%	0		
Radium and roentgen rays	15	1, or 6.67%	1, or 6.67%		0		
	121	11, or 9.1%	10, or 8.26%	1, or 0.83%		8, or 6.61%	4, or 3.3%

Table VI

Treatment	Number	Per Cent	Recovery		Mortality		Malignancies	
			Number	Per Cent	Number	Per Cent	Number	Per Cent
Surgery	125	50.8	118	94.4	2	1.6	2	1.6
Radiation	121	49.2	110	90.9			1	0.83
	246		228	91.9	2	0.8	3	1.2

CONCLUSIONS

The fact that various methods of treatment are available in uterine myomas, that the determination of the indications of treatment may be made from the symptoms, that the presenting symptoms are almost invariably associated with specific pelvic physical findings and that the age of the patient necessitates conservative methods of treatment in the young and mature women and causal methods of treatment in the menopausal and senile women, renders the treatment of uterine myomas satisfactory and successful. The methods of treatment, chosen according to the relations of the symptoms to the physical findings and the age groups, reduce errors in the selection of the form of treatment and the results of treatment have a very low mortality and morbidity and a high percentage of cure.*

* For discussion see page 887.

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IRRADIATION IN THE TREATMENT OF CARCINOMA OF THE UTERUS

WITH SPECIAL REFERENCE TO CORPUS CARCINOMA*

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THE history of gynecology may be said to have been written around the treatment of carcinoma of the uterus. The uterus contains two types of epithelium—squamous stratified, covering the portio vaginalis, and cylindrical, lining the endocervix and the uterine cavity. Thus, three types of carcinoma may develop from the epithelium of that organ: squamous cell carcinoma or epidermoid cancer from the squamous stratified epithelium, adenocarcinoma from the cylindrical epithelium of the endocervix and endometrium, and adenoacanthoma, a neoplasm made up of both types of epithelium. The results of irradiation, to a certain extent, depend upon the type of cell making up the new growth to be irradiated, the best result being obtained in the squamous cell type.

Cancer of the cervix has seen more radical changes in its treatment than has corpus carcinoma. Thomas Addis Emmet is said to have cured some cases of cervical cancer by amputation of the cervix in the pre-laparotomy days. It is conceivable that such might have been the case in very early lesions. Even in recent times every gynecologist has had the experience of amputating a cervix for what appeared to be a chronic inflammatory lesion and has had the pathologist report an early epidermoid carcinoma. Obviously, this form of treatment is useless if the disease is at all established. Then came panhysterectomy, with the removal of the adnexa and a vaginal cuff, at first performed through the vagina, later through an abdominal incision. In this country preference was usually given to the abdominal procedure, but this operation was inadequate since it did not remove the parametria nor the iliac glands. At the beginning of this century the radical pelvic dissection, popularly known as the Wertheim operation, when performed through the abdomen, and the Schauta operation when the vaginal route was chosen, was established on a sound basis. This consisted of removing the uterus, the adnexa, the parametria, after dissecting out the ureters, the iliac glands and almost the entire vagina. Naturally the results were improved by this radical method of treatment of cervical cancer. The primary mortality was high, resulting from shock and sepsis, and injury to the ureters from interference with their blood supply, or direct trauma occurred in about 20 per cent of the cases. But, despite this, it was the best method we had of treating a disease, which, when allowed to run its course, was fatal in 100 per cent of women so afflicted. I began my training in gynecology at the time the controversy existed between those who had learned to do the radical operation and the older men who were still doing an ordinary panhysterectomy with the ablation of the adnexa. The opponents of the Wertheim operation argued that it was not so much the type of operation which was done as it was the time at which it was performed in relation to the disease which influenced the results. When the radical pelvic dissection became well established, irradiation, by means of radium and deep roentgen therapy, was introduced. At first only the advanced cases, the so-called inoperable ones, were treated by this newer method, while the patients seen earlier were subjected to surgery. Through a gradual change and through improvement in irradiation, better understanding of filtration and dosage, this method has supplanted operation through-

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out the world. There are now very few clinics where cancer of the cervix is treated by surgery. Although irradiation is not entirely free from mortality, this is exceedingly low and the complications occurring after this procedure are fewer than those which follow surgery. Furthermore, a number of patients with the disease advanced beyond the possibility of surgery are cured or helped by radium and roentgen irradiation.

While these marked changes were taking place in the treatment of cervical cancer, corpus carcinoma saw no such revolution. It is a well-known fact that the squamous cell is much more radiosensitive than is the cylindrical cell. For this reason better results were obtained in treating epidermoid carcinoma with radium and roentgen rays than could be expected by irradiating an adenocarcinoma.

Again, when an adenocarcinoma of the uterine body is limited to the uterus, when it has not broken through the shell of that organ, and when it has not spread downward to the cervix in the region of the rich lymphatics of the parametria, high percentages of five-year arrests of the disease have been reported in the literature, in some series as high as 60 to 70 per cent. With that end in view, most gynecologists today feel that the treatment of corpus carcinoma should consist of an ordinary panhysterectomy, without the dissection of the ureters, removal of the adnexa and of a vaginal cuff, followed by high voltage roentgen therapy. Irradiation alone is reserved for those women who, because of some constitutional complications such as cardiac, pulmonary and renal involvements, metabolic diseases, advanced age and marked obesity, are considered poor surgical risks.

Working along these lines, since 1929, I have treated 15 patients with corpus carcinoma by means of radium and roentgen rays; these patients were considered extremely poor surgical risks, and in a number of them the disease was in an advanced stage. Five other patients were irradiated in the tumor clinic of the New England Medical Center, making in all a total of 20 patients cared for by this form of therapy. I am not attempting to compare the results of these 20 patients with the results of those who were subjected to surgery, as the comparison would not be a fair one, since I have operated on all the good risks and reserved irradiation for those where the opposite obtained. More recently William P. Healy, Henry Schmitz, H. S. Crossen, and others, have advised irradiation before hysterectomy.

My small series is presented in the form of a preliminary report in the hope of stimulating a discussion which will throw more light on the subject.

The case of a patient having an adenocarcinoma of the body of the uterus has taught me a lesson in connection with the treatment of carcinoma of the cervical stump. This woman had a supravaginal hysterectomy performed for fibroids. The pathologist discovered an associated adenocarcinoma of the body of the uterus and stated that the neoplasia extended to within 5 mm. of the cut surface of the cervix. She was subsequently given deep roentgen therapy in another hospital. I saw her in consultation on June 6, 1936, and felt that the cervical stump should be irradiated with radium. Therefore, 50 mg. of radium element, filtered through 1 mm. of brass and 1 mm. of rubber, was introduced into the cervical canal, a dose of 3,750 mc-hr. being administered. The patient made a good recovery from this and the cervix remained in good condition. Later, an enterocervical fistula appeared. This was kept under observation for some time, but, since it did not heal, the surgeon at the hospital where I had seen the patient in consultation, opened the abdomen and found that a loop of ileum was adherent to the cervical stump. The loop was separated and resected. Unfortunately, the anastomosis did not hold and the patient died of peritonitis.

Shortly after, on December 16, 1936, I had to treat another patient for a carcinoma of the retained cervix, following a supravaginal hysterectomy for fibroids performed in another city twelve years previously. In

view of my experience, I had a gastrointestinal roentgen examination made, including a barium enema. These roentgenograms showed that there was no intestine in contact with the cervix. This patient was treated by means of radium and roentgen rays, without any intestinal complications, and with the arrest of the disease thus far. Impressed by these findings, I am convinced that, in the future, I will insist upon a gastrointestinal roentgen examination before treating a cervical stump with radium. Should adhesions of the intestine to the cervix be found, I feel it would be advisable to free them before irradiating the retained cervix.

When irradiation for corpus carcinoma is reserved for the patients who are considered very poor surgical risks, the results obtained from this therapy cannot be very brilliant. However, something has been accomplished in this group of patients in the form of an arrest of the disease in some and of palliation in others. In all, it has controlled the bleeding, it has stopped the foul vaginal discharge, of which they complained, and it has given them comfort by lessening their pain. This part of the treatment has been worth while.

STATISTICS

Twenty women with adenocarcinoma of the uterine corpus were treated by irradiation by radium or by radium and roentgen rays. Fifteen of these patients were treated by me and 5 at the Tumor Clinic of the New England Medical Center. Short abstracts of their cases follow. The New England Medical Center cases are reported through the courtesy of Dr. William E. Shedden.

Case I. December 2, 1929. Mrs. E. S., aged sixty-five, an extremely obese woman, with heart disease, emphysema and arthritis, was treated with radium for adenocarcinoma of the fundus uteri at the Carney Hospital. She was given a radium dose of 7,200 mc-hr. in four sessions, 1,800 mc-hr. being administered on each of the following dates: December 2 and 31, 1929, January 28 and February 28, 1930. Her condition was such that the radium was placed in the uterus without anesthesia. Because of the arthritic condition it was very difficult to put her in the lithotomy position. She had no roentgen treatments. The histologic examination confirmed the diagnosis of adenocarcinoma. She reported at the office until September 29, 1931. A letter received from her on March 19, 1937, states that since the radium treatment she has been in the best of health, but, because of the fact that she is quite lame she cannot report to the office for another examination. She lives in a neighboring state, at some distance from Boston. She has remained well seven years and five months from the time of the initial treatment.

Case II. January 30, 1930. Mrs. M. C., aged sixty-one, an obese woman, having diabetes, was treated with radium for adenocarcinoma of the fundus uteri at the Weymouth Hospital. A dose of 3,600 mc-hr. was administered in two sessions of 1,800 mc-hr., the first on January 30, 1930, and the second on February 5, 1930. She had no roentgen therapy. The histological examination had confirmed the clinical diagnosis of adenocarcinoma of the fundus. The patient died of diabetes in November, 1936, six years and ten months after the initial treatment. At the time of her death there was no evidence of cancer.

Case III. June 24, 1930. Mrs. C. MacL., aged seventy, was treated at the Massachusetts Women's Hospital for an advanced adenocarcinoma of the fundus. She was a feeble woman, showing signs of cachexia. A radium dose of 2,400 mc-hr. was administered, which controlled the bleeding. Roentgen therapy was not resorted to because of her feeble state. The histologic examination revealed adenocarcinoma, Grade 3. She died three months after the radium treatment.

Case IV. July 2, 1930. Mrs. M. T. H., aged forty, had severe anemia following uterine hemorrhages, resulting from an adenocarcinoma of the uterine body. She was given an intrauterine radium dose of 2,400 mc-hr. She had no roentgen treatment. In October, 1930, her general condition having markedly improved, a panhysterectomy with bilateral salpingo-oophorectomy was performed in another hospital. The histologic report of the curettings obtained previous to the introduction of radium showed adenocarcinoma, Grade 2. In Febru-

ary, 1937, the patient wrote that she was enjoying the best of health. She is therefore well, six years and ten months after the initial radium treatment.

CASE V. May 8, 1931. Mrs. M. C., aged fifty-six, was treated with radium for an adenocarcinoma of the fundus, a total dose of 4,800 mc-hr. being administered in two sessions of 2,400 mc-hr. each, the first at the Leonard Morse Hospital on May 8, 1931, and the second at the Framingham Hospital on July 30, 1931. She had no roentgen treatment. The histologic examination confirmed the clinical diagnosis of adenocarcinoma. She was examined at the office in November, 1931, at which time the pelvic organs were found to be atrophied and movable. There was no evidence of cancer. On March 4, 1937, five years and ten months after the initial radium treatment the patient wrote that she was enjoying good health.

CASE VI. November 23, 1932. Mrs. E. G., a feeble patient, aged seventy-eight, having marked arteriosclerosis, was treated at the Malden Hospital for adenocarcinoma of the corpus uteri. She had one dose of radium consisting of 2,400 mc-hr. and one roentgen treatment at the same hospital on December 3, 1932. The pathologic report was adenocarcinoma of the uterus, Grade 3. This treatment arrested the bleeding. The patient was lost sight of shortly after treatment and all efforts to trace her have been futile.

CASE VII. October 12, 1934. Mrs. S. M., aged sixty-six, was treated with radium at the Carney Hospital for an advanced adenocarcinoma of the corpus. She had 4,800 mc-hr. of radium in two sessions, 2,400 on October 12, 1934, and 2,400 on December 1, 1934. This was followed by deep roentgen therapy at the New England Medical Center from December 28, 1934, to January 14, 1935. She had nine treatments, each 300 r, or a total of 2,700 r. The pathological report was rapidly growing, poorly differentiated adenocarcinoma. On June 5, 1935, she had developed marked ascites. Under local anesthesia a small midline incision was made between the symphysis and the umbilicus and a large quantity of sanguineous ascitic fluid was aspirated. She had general abdominal carcinomatosis and died on July 27, 1935, of cancer, eight months after the initial treatment.

CASE VIII. March 22, 1935. Miss B. B., a stout, asthmatic woman, aged fifty-three, and considered a poor surgical risk, was treated with radium at the Carney Hospital for an adenocarcinoma of the anterior wall of the uterus. She was given 4,800 mc-hr. in one session. This was followed by deep roentgen therapy in ten treatments from April 16 to June 25, 1935. The diagnosis of adenocarcinoma was confirmed histologically. Her last visit at the office was on November 16, 1936, at which time the abdominal, vaginal and rectal examinations showed atrophied pelvic organs and no sign of recurrence. She has remained well to date, two years and one month.

CASE IX. September 10, 1935. Mrs. M. L., aged sixty-eight, obese, hypertensive and asthmatic, was treated at the Carney Hospital for an adenocarcinoma of the corpus uteri. She was given 4,800 mc-hr. of radium. This was followed by nine roentgen treatments between October 18, 1935, and March 17, 1936. The last examination was made at the office on October 21, 1936, at which time the pelvic organs were found to be atrophied and there was no bleeding and no sign of recurrence. She has been away for the winter and has remained well up to the present time, one year and eight months after the initial treatment.

CASE X. January 20, 1936. Miss L. W., aged fifty-nine, an obese woman, with valvular heart disease and marked hypertension, was given radium therapy at the Carney Hospital for adenocarcinoma of the corpus and myomata uteri. She had in all 8,400 mc-hr. of radium, 4,800 on January 20, 1936, and 3,600 on May 20, 1936. At the time of the second application the curettings showed no evidence of carcinoma. This was followed by deep roentgen therapy at the laboratory of Dr. Frederick W. O'Brien, the dosage being 4,800 r. The diagnosis of adenocarcinoma was confirmed by the pathologist. Examination shows atrophied pelvic organs, no bleeding and no sign of recurrence, one year and three months since the initial treatment.

CASE XI. March 4, 1936. Mrs. E. B., aged sixty-nine, a feeble woman with very advanced carcinoma of the corpus and marked secondary anemia was treated at the Carney Hospital. A blood transfusion of 500 cc. was administered, and this was followed by an intrauterine application of radium, 4,500 mc-hr. being given. The pathological report was rapidly growing adenocarcinoma. She was discharged from the

hospital on March 19, 1936, the bleeding having stopped. She was advised to report to the out-patient gynecological clinic for examination and advice as to deep roentgen therapy. This she did not do and we have been unable to trace her.

Case xii. April 11, 1936. Mrs. H. R., aged seventy, was treated at the Carney Hospital. she had advanced adenocarcinoma of the uterine corpus with secondary involvement of the bladder and signs of cachexia. After a dose of 550 mc-hr. of radium she developed anuria. The radium was removed and urinary excretion was resumed after appropriate treatment. The diagnosis was confirmed histologically. She was discharged from the hospital on April 23, 1936. Her general condition was so poor that she was not referred for deep roentgen therapy. She never returned to the clinic and follow up letters have been returned.

Case xiii. January 2, 1937. Mrs. M. P., aged sixty-one, a feeble woman, looking older than her years, was treated at the Carney Hospital for what clinically appeared to be adenocarcinoma of the uterine body. She was given a radium dose of 2,400 mc-hr. The uterus was 10 cm. deep. One-half teaspoonful of curettings was sent to the pathologist, who reported that the material was too necrotic for examination. This material had been sent without delay after operation. The bleeding has stopped and the patient is under observation.

Case xiv. March 12, 1937. Miss M. L., aged sixty-nine, was admitted to the Carney Hospital on March 10, 1937, with the diagnosis of cervical polyp, fundal myoma and adenocarcinoma of the corpus uteri, Group iv (Schmitz). On March 12, 1937, the polyp was excised; material was obtained from the uterine cavity which histologically showed adenocarcinoma. She was given a radium dose of 3,600 mc-hr. On April 15, 1937, another curettage was done. The rectal examination showed the fibroid to be the size of a three months' gestation. She was given a second radium dose of 2,400 mc-hr., the total dose being 6,000 mc-hr. She was then referred to the New England Medical Center for high voltage therapy, and is now under observation.

Case xv. March 15, 1937. Mrs. C. L. N., a feeble woman, aged seventy-five, was seen at the Brooks Hospital for uterine hemorrhages. A biopsy of the cervix, two pieces, was performed, the cervix was dilated and the uterine cavity was explored with a curet, considerable friable material being obtained. The pathologist reported: "The microscopic examination of the cervical tissue and the uterine curettings showed adenocarcinoma." She was given a dose of radium of 2,400 mc-hr. This controlled the bleeding. A similar dose of 2,450 mc-hr. was given on April 12, 1936, a total dose of 4,850 mc-hr. She was then referred for deep roentgen therapy, and is now under observation.

New England Medical Center Cases.

Case xvi. December 18, 1928. Mrs. M. R., aged fifty-eight, was referred from the Tumor Clinic of the New England Medical Center for an advanced adenocarcinoma of the fundus. The pathological report stated that the tumor tissue projected from the cervix. The radium dose is not stated, irradiation being purely a palliative measure. No roentgen therapy was employed. There was no improvement and the patient died on March 13, 1929, three months after she was first seen.

Case xvii. January 17, 1930. Mrs. E. McI., aged seventy-two, was referred from the Tumor Clinic of the New England Medical Center to the Evangeline Booth Hospital where she was curetted on February 6, 1930. The pathological report was adenocarcinoma of the body of the uterus. The Medical Clinic felt that she could stand a hysterectomy, but, in view of her age, advised radium. On February 27, 1930, she was given 1,400 mc-hr. of radium in the fundus. In September, 1931, she reported that she had no symptoms but that she felt too weak to come in for examination. On December 15, 1931, she began to bleed again, her family physician felt a mass that extended to the bladder and she was having vesical symptoms. She died in September, 1932, two and one-half years after treatment, having been symptom-free for eighteen months.

Case xviii. April 14, 1930. Mrs. R. G., aged sixty-one, was seen at the New England Medical Center on April 14, 1930. On April 23, 1930, a diagnostic curettage revealed adenocarcinoma of the fundus. On May 2, 1930, she was given 6,000 mc-hr. of radium. Since that time she has refused further examination or treatment. No roentgen therapy was administered. At the present time she is free from symptoms and perfectly well, seven years after treatment.

Case xix. June 30, 1933. Mrs. E. D., aged seventy-four, a widow, was seen at the New England Medical Center on June 30, 1933, and was referred to the Palmer Memorial Hospital, where, on July 19, 1933, a diagnostic curettage was performed. The pathological report showed adenocarcinoma of the uterus. A radium dose of 3,000 mc-hr. was administered, and subsequently a second radium dose, consisting of 2,034.5 mc-hr. was given. She did not receive high voltage therapy. In May, 1936, she was given a further radium irradiation, the dose not having been stated, for recurrent carcinoma. She was without symptoms for eighteen months after the first treatment. The second treatment caused a severe reaction, lasting several months. She is now alive and ambulatory, three years and nine months after the initial radium application, but refuses further examination or treatment.

Case xx. January 26, 1935. Mrs. A. P., aged fifty-six, had had a uterine polyp removed nine years previously. In March, 1934, a biopsy of the cervix revealed cervicitis. On January 29, 1935, the pathological report from the uterine biopsy showed "papillary adenocarcinoma of the uterus." From January 29, 1935, to February 6, 1935, she was given 1,600 r, high voltage roentgen therapy, to the perineal region and anterior and posterior pelvic regions. On March 21, 1935, she was given 2,500 mc-hr. of radium and 1,620 mc-hr. on April 6, 1935. From May 17 to September 28, 1935, she received 3,200 r, high voltage roentgen therapy, distributed over the anterior and posterior pelvis, the perineum, the right groin and the right leg. The radium dose was 4,120 mc-hr., the roentgen-ray dose 4,800 r. She continued to have staining off and on during treatment. On May 17, 1935, roentgen examination showed metastasis to the right pubic bone and the question of metastasis to the right leg. On June 25, 1935, a recurrence in the anterior portion of the vagina was found. The patient died on November 26, 1935, ten months after the initial treatment.

SUMMARY

The history of gynecology has been written around the treatment of uterine carcinoma. During the last two decades irradiation with radium and roentgen rays has supplanted surgery in the treatment of cervical cancer. No such radical change has taken place in the management of cancer of the uterine body. Surgery, in the form of a panhysterectomy with the ablation of the adnexa, has given five-year arrests in 60 to 70 per cent of the cases in some series. Irradiation has been reserved, for the most part, for patients advanced in years, having definite contraindications to operation because of constitutional lesions and because of the advanced stage of the disease. Even in this group arrests have been observed, and the palliation obtained in others has been beneficial. The use of preoperative radium irradiation and surgery, and postoperative deep roentgen therapy may improve the results of the future. A small series of twenty cases of corpus carcinoma treated by irradiation is presented in the form of a preliminary report.

In this group of cases the oldest patient was 78 years, and the youngest 40 years. The younger woman had a hysterectomy four months after an intrauterine radium application, all the others being treated by irradiation alone. Two patients are alive and free from recurrence more than seven years, one patient is alive and free from recurrence more than six years, one patient died of diabetes, but was free from recurrence more than six years after the initial treatment, one patient is alive and free from recurrence more than five years. Thus, five patients, or 25 per cent, survived more than five years. Five patients, or 25 per cent, are known to have died from cancer; three others, or 15 per cent, cannot be traced, and still seven others, or 35 per cent, have been under observation less than five years.*

* For discussion see page 887.

Vol. 39, No. 6

CORRELATION OF CALCULATED TUMOR DOSES AND FIVE-YEAR SURVIVALS IN RADIATION THERAPY OF CANCER OF THE CERVIX*

A REVIEW OF 136 CASES

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EVIDENCE indicates that there are several factors influencing the prognosis in any case of carcinoma of the cervix. There is little argument today as to whether surgical or radiological methods of treatment offer a better prognosis in the majority of cases. The importance of the histological type of the tumor or the age of the patient is debatable. There is, however, fairly constant agreement that the clinical stage of the disease present when treatment is instituted is the most important factor. Most observers agree that about 60 per cent of the clinically early cases will survive five years and that a much smaller percentage (15–22 per cent) of the advanced cases will live that long. Nevertheless, all too frequently we see cases which do not follow the expected clinical course. There is the occasional early or favorable case which does not survive nearly so long as others of the same histological type which show a far greater extension of the disease. Therefore, these factors either singly or combined do not seem to be entirely prognostic.

This observation has caused us to search for other influences which may determine the course of the disease. Naturally, the question arises as to whether or not the tumor received adequate irradiation. The problem then of attempting to calculate the dose of radiation delivered to any part of the primary lesion presents itself. While such calculations for tumors located elsewhere in the body have been made[5,7,8] there has been no attempt at correlation of these doses with the end-results in a series of cases of cancer of the cervix. However Healy and Arneson[4] have compared the calculated doses with the survival rate in a small series of cancers arising in the cervical stump following hysterectomy. They point out the difficulties of obtaining a satisfactory dose of radiation in the stump. Cancer of the cervix is an ideal group for such a study. It would seem that such a study would permit an evaluation of the physical efficacy of a particular type of radiation therapy. Such calculations are necessarily only relative and their accuracy varies with the clinician's accuracy in determining the extent of the disease.

Data on the distribution of radiation throughout the pelvis from different sources of energy are available. Arneson and Quimby[2] have studied the distribution of roentgen radiation throughout the average-sized female pelvis. Isodose curves published [1,6] show the distribution of radiation in the pelvis from various combinations of vaginal and intrauterine applicators. Healy[3] has published charts giving dosages in terms of percentage erythemas delivered to different points within the pelvis from some of the more common radium applicators used by him. These latter data as well as those taken from the familiar gold seed table for the distribution of radiation from interstitial sources were used in this study.

Figure 1 is a schematic drawing indicating the position of the sources of radiation in relation to the cervix. The lettered points are arbitrarily chosen ones and are thought to represent the *probable* limits of extension of disease lateral to the cervical canal for the various clinical groups of cervical cancer. These points were chosen from a number of such points for which the distribution

* Read at the Twenty-second Annual Meeting, American Radium Society, Atlantic City, N. J., June 7–8, 1937.

of radiation is known. Point *A* is 2 cm. lateral to the cervical canal and represents a volume of tissue 4 cm. in diameter. For purposes of dosage calculation it is used to represent the estimated average maximum limits of extension of disease in the clinically early cases. While some of the very early cases may be exceptions, the majority probable average extension of disease for the various clinical groups, then they can be used as a basis for the calculation of tumor doses which are satisfactory for the question under consideration.

The plan of radiation therapy used in the treatment of cancer of the cervix at the Memorial Hospital during the year 1930

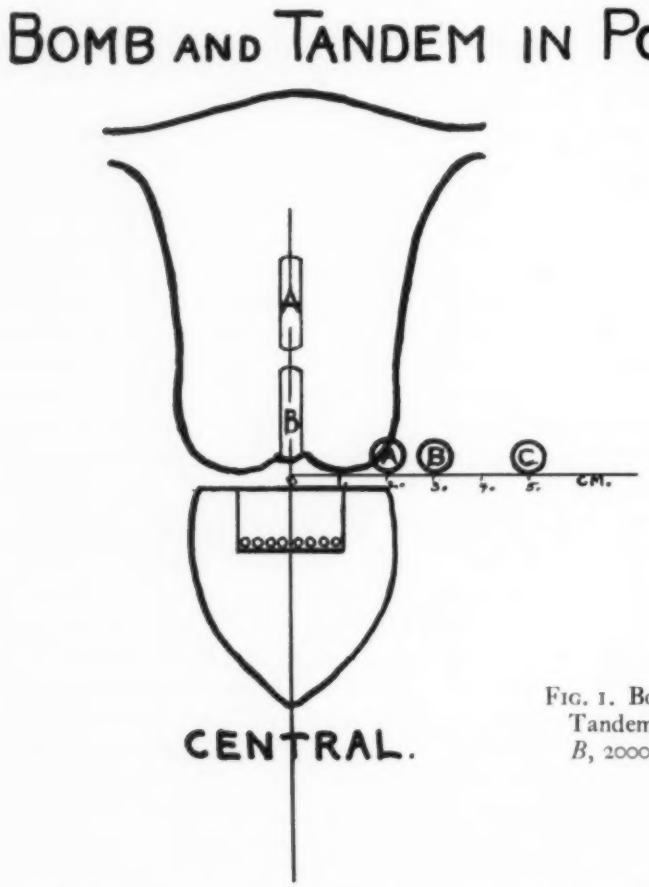

FIG. 1. Bomb = 1,500 mg-hr.; Tandem = *A*, 1,000 mg-hr.; *B*, 2000 mg-hr.

(League of Nations Group I) probably show extension this far from the cervical canal. In the same manner, the clinically Group II cases or those which are borderline are designated by point *B*, which is 3 cm. lateral to the cervical canal. Cases which are clinically Group III or IV and sometimes spoken of as advanced and very advanced respectively are all thought to have minimum extension through a volume of tissue 10 cm. in diameter or 5 cm. lateral to the cervical canal. If such arbitrarily chosen points can be used to represent the was fairly uniform. In general, a preliminary pelvic cycle of roentgen radiation was given through four pelvic fields. There were two anterior and two posterior pelvic fields measuring 10 × 15 cm. A single treatment of 700 r was given to each field using 200 kv. (peak), 4 or 30 ma., 50 cm. target-skin distance and 0.5 mm. Cu filtration. One or two weeks later, the vaginal applicator or bomb was placed against the cervix for from 1,000–1,500 mc-hr. Usually only the center position was used for the bomb, but when it was occasionally directed towards

one or both fornices, the total dose from this applicator never exceeded 3,000 mc-hr. The cervical tandem was then inserted the following day for 3,000 mc-hr. A second roentgen cycle using the same factors as before was usually given about twelve weeks following the radium. Occasionally, it was necessary to give additional therapy to resistant foci of disease which did not regress under the initial treatment. Interstitial irradiation in the form of gold-filtered radon seeds was usually used for this purpose. If more than four months elapsed between the institution of the primary treatment and these supplementary treatments, they were omitted from the calculations. Table 1 shows the known values in erythema doses for the points chosen when treatment is administered according to this plan of therapy. Variations in these doses are easily calculated. These known values form the basis of this study.

Table I

ERYTHEMA DOSES DELIVERED BY ROENTGEN RAYS AND RADIUM APPLICATORS TO POINTS WITHIN THE PELVIS

	Point A		Point B		Point C	
Applicator	T.E.D. per cent	T.E.D. per cent	T.E.D. per cent	T.E.D. per cent	T.E.D. per cent	T.E.D. per cent
Bomb—Left	15		10		5	
Center	50	125	25	175	10	60
Right	60		140		45	
Tandem—Upper	100		90		45	
Lower	710	810	370	460	130	175
Roentgen rays	100	100	100	100	100	100
Total	1035	1035	735	735	335	335

Point *A*—2 cm. from the cervical canal.
Point *B*—3 cm. from the cervical canal.
Point *C*—5 cm. from the cervical canal.
Bomb—1,000 mc-hr. each position.
Tandem—1,000 mc-hr. from upper tube.
2,000 mc-hr. from the lower tube.
Roentgen rays—One high voltage cycle assumed to deliver 100 per cent of an erythema at each point within the area under consideration.

On this basis, the doses received by cases of cervical cancer treated during the year 1930 were calculated and then compared with the five-year survivals. Of the 143 cases of primary cervical cancer treated, 136 were found to lend themselves to such calculations of the minimum dose received by the tumor. The 7 cases not calculated were eliminated because of insufficient data to permit of such an evaluation. The survival rates given, then, do not differ widely from the routine statistical report of five-year survivals.* Each case was analyzed critically in an effort to determine the maximum limits of extension of the disease when treatment was instituted. The point of maximum extension of disease is of importance naturally as it is the one to which a satisfactory dose must be delivered in order to control the disease. Such limits are based on the clinician's impression of the stage of the disease. The clinical diffi-

* Due to the fact that treatment data were insufficient for purposes of dosage calculation in 7 cases, the five-year results presented differ slightly from the actual survival rate for that year.

On the basis of the 143 cases treated in 1930 five-year survivals were:

Total cases	143	Total cases lived 5 yr.—	41 28%
Early	24	Total cases lived 5 yr.—	14 58%
Borderline	20	Total cases lived 5 yr.—	7 35%
Advanced and very advanced	99	Total cases lived 5 yr.—	20 22%

The differences in the various groups and for the total cases is uniform and does not affect the validity of the argument.

culty of establishing such limits is obvious and the relative value of the arbitrary points chosen becomes apparent.

The distribution of the calculated cases according to clinical stage of the disease and the five-year survival rate is shown in Table II.

TABLE II

CLINICAL STAGE OF DISEASE AND FIVE-YEAR SURVIVALS

Clinical Groups (League of Nations)	No. Cases	Survivals	
		No.	Per Cent
I (early)	23	12	52.1
II (borderline)	19	6	31.5
III and IV (advanced and very advanced)	94	16	17.0
Total	136	34	25.0

The calculated tumor doses received by these cases and the survival rate according to the dose received are shown in Table III. It is obvious that cases clinically early generally received large minimal tumor doses and the advanced and palliative cases received small minimal doses. The borderline cases received doses intermediate between these two groups.

Reference to Table I shows the impossibility of delivering larger doses of radiation to distant points within the pelvis from the applicators and dosages used. It is therefore evident that the majority of cases treated by this method did not and could not receive a dose of radiation to the outlying parts of the tumor sufficient to control the disease. Ninety-five of the cases, or 69.8 per cent, received less than 6 T.E.D. This is practically the same percentage of cases as fall in the clinical Groups III and IV. The necessity of increased dosage to this group in order to increase the five-year survivals is obvious. As the calculated dose of radiation increases the improved five-year survivals become evident. It is interesting to note that only 19 per cent of cases receiving less than 6 erythema doses survived five or more years while 39 per cent survived of those receiving more than this amount.

CONCLUSIONS

On the basis of data presented, the conclusion that the method of radiation therapy used in 1930 was far from being satisfactory in clinical Groups III and IV as measured by five-year survivals is drawn. Since these groups comprise approximately 70 per cent of all cases of cancer of the cervix seen, it would seem that other methods of radiation therapy are justified. Such methods should strive to increase the dose to the parametria without causing irreparable damage to vital structures. Our efforts in this direction have thus far been chiefly confined to the use of divided dose roentgen rays. Since this method has increased the

TABLE III

CALCULATED TUMOR DOSES AND THE FIVE-YEAR SURVIVALS IN 136 CASES OF CARCINOMA OF THE CERVIX

Clinical Groups (League of Nations)	No. Cases	Calculated Threshold Erythema Doses				
		Less than 3	3–6	6–9	9–12	More than 12
I	23	0	1	2	14	6
II	19	0	5	12	2	0
III and IV	94	62	27	4	1	0
Totals	136	62	33	18	17	6
Five-year Survivals						
Number	34	10	8	4	8	4
Per cent	25	16	24	22	47	67

parametrial dose from 1 T.E.D. only up to approximately 2.5 T.E.D. it is possible that further efforts may lie in the use of interstitial sources as advocated by some writers.

SUMMARY

The minimum doses of radiation have been calculated in terms of threshold erythemas delivered to 136 cases of primary carcinoma of the cervix. Calculations were based on data available for the distribution of radiation throughout the average-sized female pelvis. The arbitrary points used for estimation of the average extension of disease in the various clinical groups are of relative value only. Their applicability to a particular case varies with the clinical estimation of the extent of the disease.

The importance of such calculated doses is seen when they are correlated with the five-year end-results of the cases thus treated. Tables presented indicate that very few of the advanced cases received an adequate dose to the tumor and accordingly few of them survived the five-year period. Only 19 per cent of the cases receiving a calculated tumor dose of less than 6 erythemas survived. As the calculated dose increases, the percentage of five-year survivals improves so that those cases receiving a calculated dose of 9 or more erythemas showed 52.1 per cent survivals.

Seventy per cent of the cases were either advanced or very advanced and in these the disease had extended into the parametrium for a distance of at least 5 cm. lateral to the cervical canal. In these, the calculated dose was generally low and the survival rate correspondingly poor. The conclusion is drawn that any method of radiation therapy delivering less than 6 erythemas to the parametrium will fail to control the disease in the majority of the cases.*

I wish to express my thanks to Dr. William P. Healy, Attending Gynecologist of the Memorial Hospital for permission to study these cases and for his many helpful suggestions and criticisms, and to Mrs. Edith H. Quimby of the Physics Department of the Memorial Hospital who suggested this study and without whose assistance it would not have been possible.

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* For discussion see page 887.

PALLIATION OF CANCER IN GYNECOLOGY*

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IN THE healing art of medical practice it is human nature to like to show miracles; the greater the miracle, the greater the satisfaction in the showing. In the treatment of lethal disease it is natural to measure success or failure by life or by death. In the treatment of cancer the specialist delights in reporting his so-called "five- and ten-year cures," whether accomplished by destructive major surgery or by the use of physical agents. Very little is said about the patient's discomfort, disfiguration, or obnoxious condition following attempted cure. The twin Grails—Cause and Cure—are sought with such scientific avidity that relatively little is taught about judgment as to when not to treat cancer patients. Lee,[1] has shown that in advanced cancer of the breast the curve of life for treated patients is almost identical with Daland's curve of life for patients not having treatment. The urge to do something for the patient expends itself too often in merely doing something to her.

Many cancer institutions are training young men to operate upon and to scientifically treat patients with malignant tumors. If the patient survives the treatment and is able to return to well-organized follow-up clinics, the intern sees his, or his predecessor's, successes, and possibly the failures in the early part of their decline, while they are still ambulatory. It is only when he has graduated from his internship and is put upon his own resources that he finds that patients too ill to return to his office cannot all be shunted to a home for incurables where someone else will follow them through to the end. He then finds that the cancer specialist is expected to offer some palliative relief for the distressing symptoms of advanced cancer. Possibly that is why so many hopelessly advanced patients come clamoring for admission to cancer institutions with the perhaps flattering passwords, "My doctor has been treating me for months, has been doing all he can for me and now advises that I come to a cancer institution where they have everything to work with." It is as ridiculous for an untrained man to treat cancer simply because commercial firms have made the rental of radium easy as it is for the average physician to attempt brain surgery because he can rent usable instruments.

How great a part does palliation play in the treatment of malignant tumors? Of patients presenting themselves for the first time at Memorial Hospital: 50 per cent of those suffering with cancer of the vulva already have palpable inguinal glands; two-thirds of these developed glands after they had placed themselves under the care of a physician; the five-year salvage in this group is about 15 per cent; 85 per cent of those having cancer of the cervix already have the disease extending beyond the portio vaginalis (i.e., are beyond the early and favorable stage); total five-year salvage of advanced cases is about 15 to 18 per cent; 59 per cent of those having cancer of the corpus uteri already have pelvic fixation or distant metastases (i.e., are in the advanced stage). This five-year salvage is about 40 per cent; 78.5 per cent of patients with carcinoma of the ovary have already had simply an exploratory celiotomy or an incomplete operation. This five-year salvage is less than 20 per cent.

From the record it is evident that, in spite of pleas for early diagnosis and the knowledge that the best treatment for cancer is prophylaxis, the majority of patients presenting themselves to cancer institutions are still patients with advanced disease, and the treatment of advanced cancer is purely the palliative attempt to give relief from symptoms.

[1] Lee, B. J. Therapeutic value of irradiation in treatment of mammary cancer. *Ann. Surg.*, 1928, *88*, 26–47.

* Read at the Twenty-second Annual Meeting, American Radium Society, Atlantic City, N. J., June 7–8, 1937.

The symptoms requiring palliative relief are the cardinal symptoms of cancer: pain, hemorrhage and obnoxious discharge. All are late symptoms and mean advancement of the disease.

Pain is manifested either by direct pressure or by direct involvement of sensory nerves, or it may appear as discomfort from the size and location of the tumor with the resultant embarrassment of respiratory, urinary or intestinal functions. Palliative relief of pressure discomfort may be achieved by the removal of bulk, as in vulvar or ovarian tumors, or by frequent paracentesis for ascites. Many drugs give temporary relief for cancer pain, but all require substitutions in a relatively short period of time. Compounds of the salicylates seem to be the most satisfactory in the first stages of pain. As these become inadequate, codeine, starting with small doses, is the most valuable narcotic. The use of morphine in the early stages of cancer pain is one of the mistakes most often encountered. Patients rapidly acquire a tolerance for large doses until very soon even huge doses fail to give relief. Morphine should be reserved for the last few weeks of the terminal stage. The present-day substitutes for morphine have the same faults and in most instances fail to equal the efficiency of morphine. Alcohol injections, chordotomy, and hypogastric sympathectomy—with their admitted limitations—all have their place in the relief of terminal pain.

Hemorrhage, always a manifestation of friability of tissue and blood vessel involvement, can often be controlled by physical agents—as the actual cautery or by irradiation. Patients with low hemoglobin or red cell count should be transfused repeatedly, as anemic patients tolerate poorly either irradiation or post-cautery slough. The low blood volume of cachectic patients often gives a misleading red blood cell count.

Obnoxious discharge, evidence of necrosis of tissue, and invasion of lymphatics, requires relief. The sloughing, fungating, bulky tumors of the vulva and cervix can be greatly reduced with the cautery. The lesions can be cleaned to an astonishing degree by the use of pressure sprays and removal of the necrotic tissues. Dakin's solution, peroxide, or sodium perborate are most useful in this situation. The use of the preliminary, prolonged, divided dose method of external roentgen irradiation for carcinoma of the cervix causes much of the infected sloughing lesion to disappear before patients are admitted for the local application of radium. Some patients formerly rejected as hopeless now respond symptomatically quite favorably to external irradiation alone, administered as a palliative measure.

Pyometra is most commonly found with carcinoma of the corpus, but is also too frequently present with carcinoma of the cervix. It is associated with cervical cancer most frequently in hopelessly advanced, untreated cases. The incidence after treatment is slightly higher in early than in advanced cases. There has been some slight increase in the incidence of pyometra with cervical cancer at Memorial Hospital in the past few years. I believe this is due to the increased time interval between preliminary external roentgen irradiation and the dilatation of the cervix at the time of radium insertion. There is no appreciable difference in the incidence of pyometra, whether patients are treated by divided dosage or by massive dosage roentgen technique. Since more than one-third (39 per cent) of patients with pyometra have retroverted uteri, and since more than three-fourths (77 per cent) of patients with pyometra have it before any treatment is given, we can assume that it is primarily the result of uterine postural state. It is, however, a serious complication and the methods of treatment to date—irrigation after drainage, with or without hysterectomy—are not satisfactory and are certainly palliative only. Probably an earlier correction of the retroverted uterus would require less palliation in the later stage.

Fistulae. In a published review[2] of 2,852

[2] Smith, F. R. Incidence of vaginal fistulae in patients with carcinoma of cervix. *Am. J. Cancer*, 1934, *22*, 52–58.

case histories of patients treated at Memorial Hospital for carcinoma of the cervix between 1916 and 1932, I was able to show that the incidence of vaginal fistula in carcinoma of the cervix is primarily a manifestation of the advancement of the disease, the incidence in that study being twice as high in untreated as in irradiated patients. Recent further study of 567 patients treated from 1933 to 1936 has confirmed this finding, the incidence of fistula here in untreated patients being more than three times as great as in irradiated patients. As infection was also found to be an important factor in fistula formation, the cleaning up of infected lesions with preliminary external roentgen irradiation should help to prevent formation of vaginal fistulae. The incidence of fistula was no higher with divided dosage than with massive dosage roentgen technique. Untreated patients with vaginal fistulae appearing for the first time should be rejected as too far advanced for beneficial therapy. Any therapy will only add to their discomfort. The repair of any fistula appearing after radiation therapy should not be attempted until the patient has remained free from disease for five years after the appearance of the fistula.

In carcinoma of the ovary we have what I believe is the one exception to the time-honored axiom "once inoperable, always inoperable." Several patients explored and closed as hopeless have been treated palliatively by external irradiation, repeatedly tapped, and, one or two years later reoperated and the bulk of the devitalized tumor removed with recovery for a period of years.

In carcinoma of the cervix, the 15 to 18 per cent so-called five-year cures in patients with clinically advanced disease (i.e., have palpable glands in the parametria) may not be the miracles that they so often are claimed to be, for the glands are not proved microscopically to be cancer but are merely clinical interpretations. We know that in cancer of the vulva one-third of the patients with palpable inguinal nodes have been shown microscopically to have merely hyperplastic lymph glands, free from cancer.

The following are a few examples of palliative treatment of cancer in gynecology.

REPORT OF CASES

CASE I. L. C., aged sixty-four, first appeared at Memorial Hospital on March 3, 1935, with myosarcoma of the vulva; married forty years; 4 children, the youngest twenty-six years old; no miscarriages; menopause at fifty-three. *Symptoms:* pruritus vulvae for nine months; first noticed a non-ulcerative lesion on left labia two months ago which grew rapidly and began to ulcerate four weeks ago. The lesion was on the left labia, 4×3×3 cm., but fairly movable and fungating. No gross palpable glands on either groin. *Treatment:* local vulvectomy under novocaine infiltration locally. Pathology report G792: "Smooth muscle sarcoma." Photograph taken July 29, 1936, shows no evidence of recurrence. The patient leads a normal life two years later. There is some induration of the vulva but no erosion, no frank evidence of recurrence. The patient continues her housework.

CASE II. H. S., aged fifty, widow, white, first seen August 12, 1928, one month following an exploratory operation and attempted hysterectomy. Intraperitoneal biopsy, taken from the parametrium, had revealed a "plexiform epidermoid carcinoma, Grade 2." The patient presented a cratered cervix with fixation and definite parametrial infiltration that no surgeon should have even attempted to remove. The patient also had an ankylosed left hip, hypertension 210/120, and a right inguinal hernia. It was felt that the case was too far advanced to treat, but, because of family pressure to attempt to alleviate the bleeding and troublesome discharge, the patient was given a pelvic roentgen series of 700 r to each of four portals. This was repeated two months later with such surprising results that six weeks following the second pelvic series, 1,000 mc-hr. of radium with a vaginal bomb was applied against the cervix, followed one day later by a cervical tandem of 3,000 mc-hr. placed in the cervical and uterine canal. Three weeks later six gold seeds of 1.96 mc. were placed in the cervix giving 1,564.08 mc-hr. Four months later the radium reaction had completely subsided, and

she has remained well and has been taking full charge of four grandchildren—8¾ years from the time she was first seen with what seemed hopelessly advanced disease. Today, she is in the hospital having had a right kidney stone removed. There is no evidence of cancer present.

Case III. M. R., aged twenty-two, married, first seen at Memorial Hospital August 27, 1931; menses normal; never pregnant. Present illness began thirteen months previously with lump in groin which was incised and never healed. Six months later both groins were dissected and exploratory celiotomy performed. On admission, a fungating, bleeding, raised, rectangular lesion 11×6×1 cm. presented in the left groin. There was thickening in both pelvic adnexa. Biopsy showed "diffuse carcinoma, ovarian in origin." Roentgenograms of the chest showed no evidence of metastasis. *Treatment:* A series of roentgen treatments, 500 r to each of four pelvic portals and repeated at two-day intervals; total 1,000 r to each portal. The lesion in the left groin diminished to 3×2 cm. with practically no elevation within one month. Three months later (November 16, 1931) the left groin was given 16,000 mc-hr. at 6 cm. distance with the radium element pack. Three months later the lesion was completely healed. One year later there was some discoloration of the left groin; roentgenograms of the chest were negative for metastasis. The patient had worked and supported herself for one year. One month later a cellulitis appeared in the groin and fourteen months from the first treatment at Memorial Hospital a recurrence appeared. She was then given 150,000 mc-hr. with the radium pack at 15 cm. at two-day intervals to left groin. Cachexia increased, and she died sixteen months from time of palliative treatment, having worked thirteen months after treatment.

Case IV. H. L., aged twenty-nine, married but never pregnant, appeared at Memorial Hospital April 14, 1932, with a frozen pelvis and a hard mass in the right lower pelvis twice the normal size of adnexa. One month before, she had had a celiotomy with left oophorectomy for what proved to be an embryonal carcinoma. Radium had been placed in the uterine cavity, 1,800 mg-hr. Treated at Memorial Hospital with the 4-gram element pack—8,000 mc-hr. daily at 15 cm. distance, alternating daily anterior and posterior, 80,000 mc-hr. being given to each anterior and posterior portal. Within two months the mass had entirely disappeared, although there is still some induration in the right pelvis. The patient has been well and working daily for the past five years.

Case V. C. V., aged twenty-nine, white, single, first seen at Memorial Hospital April 5, 1928, with a recent suprapubic midline scar and a mass the size of a seven months' gestation filling the abdomen. The patient had never menstruated, and, three years before her first visit to us, had had a simple cyst of the ovary removed. Six months before her first visit to us, she had noticed enlargement of the abdomen, and, six weeks before her first visit, an exploratory celiotomy had revealed a hopeless carcinoma of the abdomen, and only biopsy was performed. Pathologic report by Dr. Ewing was "very cellular embryonal carcinoma, characteristic of embryonal ovarian carcinoma." Roentgenograms taken May 16, 1928, showed no evidence of chest metastasis. *Treatment:* 80,000 mc-hr. radium with the 4-gram element pack to each anterior and posterior abdominal portals at 15 cm., 8,000 mc-hr. being given daily. Within one month the mass had entirely disappeared and the patient returned to work. Two months later treatment was resumed (having allowed this time for skin recuperation) and 50,000 mc-hr. was given similarly before skin blistering prevented further therapy. This patient has not missed a day's work in nine years. There is marked telangiectasis of the abdominal wall.

Case VI. S. G., aged forty-five, admitted to Memorial Hospital May 17, 1925, complaining of abdominal pain and swelling. The abdomen had a movable hard mass, extending up to the umbilicus and ballotable in ascitic fluid. Operation, May 20, 1925 (exploratory celiotomy), showed a papillary cyst carcinoma of the right ovary with implants in the intestines and in the splenic and hepatic gutters. Biopsy only was performed and showed papillary cyst carcinoma. Paracentesis was performed every two or three weeks for two years (over 40 tappings) and the patient received two pelvic series of roentgen therapy three months apart, 140 kv. being used in four pelvic portals to skin tolerance. One year later, one high voltage (200 kv.) roentgen series was given through the same four portals (750 r to each portal). As the patient continued to form ascites but failed to

develop cachexia, she was again operated upon, July 12, 1927, and both papillary ovarian tumor masses were removed *en bloc*. The uterus was not removed. The metastatic implants found in the lateral gutters at the previous operation had entirely disappeared. Three weeks postoperative, 12,000 mc-hr. of radium was given over the abdominal wound at 6 cm. distance, and six weeks later 700 r roentgen radiation delivered to each of four pelvic portals. There was no ascites after the second operation and the patient resumed her household duties in September, 1927. The abdomen showed telangiectasis following repeated irradiation. There was thickening in the pelvis on either side of the uterus, but the patient was in good health for nine and a quarter years following the second operation, and eleven and a half years following her admission to Memorial Hospital. In December, 1936, there was evidence of activity and a mass was palpable in the abdomen that felt like growth in the omentum. An exploratory celiotomy revealed widespread active carcinomatosis of the peritoneal cavity, and the patient died March 4, 1937, twelve years after her first admission to Memorial Hospital.

These patients are not shown as "cures" but as arrested disease for varying lengths of time as examples of palliation of cancer in gynecology.*

* For discussion see page 887.

VOL. 39, NO. 6

INTESTINAL INJURIES AFTER RADIUM AND ROENTGEN TREATMENT OF CARCINOMA OF THE CERVIX*

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FOLLOWING an increase in radium and roentgen-ray dosage for carcinoma of the cervix there occurred a group of injuries of an ulcerative type, limited to the mucosa of the intestine, which had been observed previously only once in this clinic. These lesions differed from the majority of those reported by many authors and collected by Flaskamp[11] and Desjardins[7] in that the injury, instead of being part of a general destructive process involving uterus and vagina or the body surface, was limited in extent to a small segment of the large bowel, indicating that modern technique has made it possible to administer a dose just sufficient to injure the specifically susceptible intestinal mucosa without affecting seriously the intestinal muscularis, bladder, uterus or skin, although these may have received equal or heavier doses of radiation. It seems important to report these cases together with the dosage factors: (1) to point out to those who may observe cases of intestinal obstruction or ulceration of the rectum or sigmoid, in patients who have been treated for carcinoma of the uterus, that the condition may be the result of radiation injury to the intestine and not caused by carcinomatous involvement; (2) to draw attention to the possibility that diarrhea, abdominal distress and nausea occurring during treatment may be symptoms of a definite injury to the intestinal mucosa and not of a general radiation sickness; (3) to warn therapists who, by increasing their radiation dosage to a level necessary for efficient cancer therapy, run the risk of causing similar injuries; and particularly (4) to emphasize the importance of the time factor in dosage. This emphasis on the time factor is timely since, in the published descriptions of techniques, dosage is nearly always expressed in unqualified milligram-hours, and in public discussion and private conversation the importance of the time factor is often either denied or ignored.

In our cases the radiation injuries were eliminated without reducing either the total milligram-hours or roentgens administered. This was accomplished by reducing the number of milligrams used in the uterovaginal applications from 175 to 70 and increasing the duration of the application from 40 to 100 hours; by reducing the daily roentgen dose from 300–400 r to 100–200 r and the size of the field from 20 × 20 cm. or 15 × 20 cm. to 10 × 15 cm. or less and increasing the duration of the course of treatment from twenty-one to thirty days to forty or more days. Following this change in technique the incidence of intestinal injuries, which had been 8.7 per cent, dropped to nil. It was decided to review all cases of intestinal injury in the hope that the difference between obvious overdosage on the one hand and the causes of the injuries limited to the intestine might be brought out.

In the records of 350 cases of carcinoma of the cervix and in 92 cases of carcinoma of the corpus treated by radium, symptoms related to the lower alimentary system were noted in 139 patients. This number is probably incomplete because of the failure to note trivial symptoms, and because of the incomplete reports of the terminal symptoms of patients dying at home or in institutions where records are imperfectly kept. The observed conditions have ranged

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from the simplest proctitis through more severe inflammation (16 cases) to ulceration (12 cases), cicatricial stenosis (1 case) and perforation (5 cases). One case of obstruction by kinking of an uninjured intestine and 2 cases of obstruction complicating persistent carcinoma are also reported.

In the following case reports radium tubes were placed in the uterus and cervix end-to-end in sufficient numbers to occupy the length of the canal. The filtration of these tubes was 1 mm. platinum and 1 mm. rubber. The vaginal applicators consisted of similar radium-bearing tubes each surrounded by cork, rubber or gauze 5 mm. thick. One applicator was placed in each lateral fornix with the ends directed towards bladder and rectum and one against the cervix. The bladder and rectum were firmly forced away by gauze packing. The technical factors used for roentgen therapy in all our cases were 200 kv., 50 cm. distance, 1.5 Cu or 2 mm. Cu plus 1 Al filtration. The total dosage and number of fields of irradiation are given in the individual case reports.

SUMMARY OF CASES

In the cases reported the symptoms, physical signs and findings at operation or autopsy presented pictures of varying degrees of intestinal injury from the mildest type causing a simple proctitis, through various stages of destruction, to gross necrosis terminating in perforation or cicatricial repair with varying degrees of stenosis or atrophy. Diarrhea and nausea were frequently present during treatment and usually disappeared within a few days after interruption of the treatment. The only objective sign was congestion of the mucous membrane of the rectum and sigmoid. Whether these symptoms were due to the direct effect of the radiation on the intestinal epithelium or to a more general intoxication is open to discussion, but experimental evidence and the observed conditions in those patients who came to operation or autopsy leads us to believe that there was a true radiation enterocolitis.

In 16 cases abdominal cramps and diarrhea with mucous and blood streaks in the stools suggested a more intense irritation. There was occasionally slight lower abdominal tenderness. The mucous membrane of the rectum and sigmoid were swollen, red and dotted with numerous punctate hemorrhagic spots. Roentgenological examination showed spasm of the rectosigmoid in 6 cases. These more severe manifestations were a continuation of those experienced during treatment or shortly after its termination and lasted up to four months. All healed spontaneously. There have been no late sequelae noted except atrophy of the rectal mucosa.

Ulceration occurred four times in the rectum (Fig. 1*A*) (Cases I, II, III, IV); four times in the rectosigmoidal region (Fig. 1*B*) (Cases V, VI, VII, VIII); twice in the loop of the sigmoid (Fig. 1*C*) (Cases IX, X) and twice in the small intestine (Cases XI, XII).

Symptoms. In the cases of injury to the rectum and sigmoid the symptoms at the onset were alike: abdominal cramps, diarrhea, frequent and bloody stools. The onset in the rectal cases occurred during treatment in 1 case, five months after the end of treatment in 2 cases and two months after treatment in 1 case. The symptoms persisted for one year, eight months and three months (2 cases). Recovery was spontaneous. In the cases of ulcer of the rectosigmoidal region the symptoms began after five months (2 cases), two months and eleven months. The first 2 cases recovered spontaneously after seven months and one year respectively. In Case VI signs of obstruction occurred two months after the onset of symptoms. At operation attempts to free the intestine failed. Colostomy and tamponade of the pelvis was followed by progressive asthenia and death after sixty-nine days. Obstruction occurred rapidly in the other patient (Case VII). A colostomy and cholecystectomy were performed. Death occurred from pneumonia six days after operation.

Two patients with a lesion in the loop of the sigmoid showed signs of obstruction

four months and five months respectively after treatment. The onset was gradual in both cases. Case IX, treated by colostomy, is well two years. Case X, similarly treated, died of a hemorrhage from the colostomy wound three months after operation.

Two patients suffered injury to the small intestine. In Case XI (see Table 1) the nausea, vomiting and diarrhea present during treatment became aggravated. There was necrosis of the skin and a picture of a chronic peritonitis. Death occurred two months after completion of the treatment. At autopsy there was injury to the small intestine throughout the lower abdomen and a diffuse fibrinopurulent peritonitis without perforation of the intestine. Case XII had similar symptoms and the same abdominal findings at operation. Although no specimen of the mucosa of the small intestine was obtained, the clinical picture was so similar to Case XI that it is reasonable to assume that the pathological condition of the intestinal mucosa was identical. Death occurred eight weeks after the operation. The occurrence of peritonitis without perforation draws attention to the increased permeability of the injured intestine to bacteria (Warren and Whipple).[33-36]

Anatomic Findings. In the 4 rectal cases (Fig. 1*A*) (Cases I, II, III, IV) there was an indurated area on the anterior wall, 1 or 2 cm. in thickness and 4 to 6 cm. in diameter, with its lower margin 4 to 6 cm. from the anus. In the center of this area was a vertical linear or stellate ulcer 1 to 1.5 cm. in diameter with a gray sloughing base and a raised nodular edge about which the mucous membrane was swollen and red.

Two specimens from the rectosigmoidal region (Fig. 1*B*) were observed. In one (Case VII) there was an ulcer 4 cm. wide involving the whole circumference of the gut. It was slightly excavated with flat edges. The base consisted of a grayish slough. Beneath the ulcer the intestinal wall was slightly thickened. The peritoneal surface was intact. The distance between the ulcer and the fundus of the uterus was about 4 cm. Microscopically there was

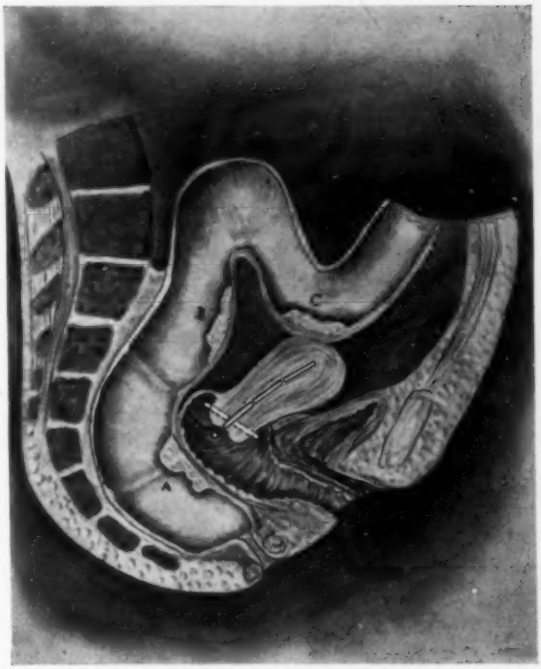

FIG. 1. Diagram showing the sites of injury in the lower bowel: *A*, in rectum adjacent to vagina; *B*, rectosigmoid at some distance from cervix; *C*, a loop of sigmoid adherent to fundus.

almost complete necrosis of the mucosa. The submucosa and inner layer of the muscularis showed a slight cloudiness of the cells, a marked infiltration with polymorphonuclear leukocytes and plasma cells and a moderate growth of scar tissue. In the other (Case VI) there was complete necrosis of a portion of the anterior wall of the rectosigmoid. The length of time since the termination of treatment (eleven months) aroused some doubt as to whether irradiation had been the cause of the injury. There seemed, however, to be no other explanation. In Case IX a loop of the sigmoid was intimately attached to the fundus of the uterus and bladder by fibrinous adhesions. The diameter of the gut was narrowed but the wall was firm and evidently thickened. The surface was rough and deeply congested (Fig. 9; cf. Fig. 6 for roentgenogram).

The specimen of ulceration of the small intestine with chronic fibrinopurulent peritonitis (Case XI) showed a marked destruction of the mucous membrane (Fig. 10).

The muscularis was relatively unharmed.

Intestinal Obstruction (Case XIII), aside from that associated with ulceration, occurred once because a loop of small intestine was caught in an inflammatory pelvic mass following the application of radium to an extensive carcinoma of the cervix. At the original examination the ulceration extended nearly to the right pelvic wall. At operation for the obstruction, there was no gross evidence of radiation injury to the intestine itself. Following ileostomy and later intestinal anastomosis, the patient has remained well five years. In 2 cases the obstruction was caused by an extension of the disease throughout the pelvis. In one of these (Case XV) there was also roentgen evidence of intestinal injury (Fig. 8).

Rectovaginal fistula has occurred five times within the limits of our observation. All were accompanied by a continuance of the carcinoma. In one case, however, the injury might be ascribed to overdosage of radium applied to a carcinomatous cervical stump. A total dose of 6,000 mg-hr. was given in a period of forty hours.

ROENTGENOLOGIC ASPECTS

The importance of roentgenological examination in the diagnosis of intestinal injury following radiation therapy is illustrated by the fact that 21 out of 35 cases with intestinal symptoms studied during 1933, 1934 and 1935 showed a demonstrable change in the contour and mucosal pattern of the affected segment. The intestinal tract was studied by means of repeated barium enemas, occasionally supplemented by the barium meal orally, ingested a few hours previously. The sigmoid was by far the most common location of post-irradiation injury. Of the 21 cases studied, the sigmoid was involved in 10, the rectum in 6 and the ileum in 2, and in 3 cases the lesions were found both in the sigmoid and the rectum.

In general there seemed to be a direct relationship between the severity of the patient's gastrointestinal symptoms and the extent of the lesion in the intestine. In 11 cases with slight tenesmus, mild diarrhea and occasional bleeding the roentgenologic examination showed localized spasm, with little or no exaggeration of the mucosal folds. However, in 10 patients with symptoms of marked abdominal cramps, vomiting and bloody stools, the roentgen examination by means of the barium enema usually revealed a varying degree of stricture, persistent spasm and markedly exaggerated mucosal folds with serrated margins of the involved segment. In one instance, the annular constriction was so pronounced that a malignant new growth could not be ruled out (Case IX, Fig. 6). In another case there was almost complete intestinal obstruction (Case X, Fig. 7).

Six of the cases with striking changes in the colon have been examined at three, six and twelve months, or longer intervals. In 2 cases the lesion remained unchanged during a period of ten to twelve months. In the remaining 4 instances the exaggerated mucosal folds remained persistent. However, the lesion appeared more localized than before and the caliber of the lumen showed restitution to almost normal (Case V, Figs. 2 and 3).

The follow-up studies, so far as our roentgenological data permit, seem to confirm the anatomic findings, that the injurious action of irradiation is selectively on the intestinal mucosa, with practically no effect on the muscular coats. Furthermore, the maximum injury in the majority of the cases is in the fixed portion of the lower colon, particularly at the distal end of the sigmoid.

With respect to differential diagnosis, a malignant growth, or extension of the primary neoplasm from the cervix should be ruled out. A malignant lesion of the colon, like post-irradiation colitis, occurs more frequently in the sigmoid. The margins of the constricted segment are usually smooth due to invasion and destruction of the mucosa. The intestine close to a malignant growth is normal in appearance and there is usually a palpable mass present, whereas

in sigmoiditis, due to radiation therapy, there is usually a marked exaggeration of the mucosal folds. The marginal irregularity seems to extend beyond the site of the lesion. The constriction is flexible and may be altered by pressure of the barium fluid. Sigmoiditis may occasionally cause a complete obstruction, in which case a differential diagnosis is difficult.

TREATMENT

The treatment of the ulcers of the intestine following irradiation was palliative until signs of obstruction appeared. Paregoric gave excellent results. A bland diet with mineral oil seemed definitely to have relieved discomfort at stool. The operative treatment of the obstruction was satisfactory when simple colostomy could be performed. Where an attempt was made to remove the affected area, the result was unsatisfactory. Cholecystectomy in addition to a colostomy proved fatal in Case VII. It is apparent that these patients are not good surgical risks and that one should employ the simplest procedure possible.

CICATRICIAL DEFORMITY

Cicatricial deformity of the rectum was observed in four forms. Following the treatment of an extensive carcinoma of the cervix there was often a deformity of the anterior rectal wall due not so much to injury to the rectum itself as to cicatricial contraction of the parametrial tissue which formed a semilunar, leathery ridge 6 to 8 cm. from the anus, extending from one side of the pelvis to the other and measuring 1 or 2 cm. vertically. The rectal mucous membrane over it was smooth and flat and contained numerous telangiectases. The only symptom observed was discomfort at stool. There was never any obstruction. It is of interest chiefly because of the difficulty in distinguishing this induration from a persistence of the carcinoma in the parametrium. The second form is an annular stricture without previous demonstrable ulcer. It was observed once in a patient treated by radium for an adenocarcinoma of the corpus. There was an annular constriction beginning 3 cm. from the anus and extending upward about 4 cm. It was irregular, with a sensation of thin bands of scar tissue beneath a mucous membrane which was pale and thin and showed a few telangiectases. The third form of cicatricial lesion is atrophic in appearance and is very common. In the cases studied the mucous membrane over the anterior rectal wall for an area 5 to 6 cm. in diameter was pale and transparent. It was crossed by a network of telangiectases which bled spontaneously or when rubbed by a soft sponge. The only symptom was an occasional blood streak in the stool. The fourth type is the puckered scar which follows the healing of the ulcers described above. In Case IV a small area of induration covered by a small, stellate scar still persists after eleven years.

DISCUSSION

The susceptibility of the intestinal mucosa to radium and roentgen radiation has long been known. Experimentally it has been especially well demonstrated by Warren and Whipple,[33–36] and by Martin and Rogers,[20] and reviewed by Desjardins.[7] There appears first a spastic contraction of the intestine; within one hour (Keller[15]) there is infiltration by polymorphonuclear leukocytes and in ten hours (Krause and Ziegler[18]) early degenerative changes. There proceeds a degeneration of the elements of the mucosa, hyperemia, vascular degeneration, hemorrhagic and fibrinous exudate and atrophy of the villi. The muscularis is affected only by large doses. Repair may be complete without cicatrization but usually there is a slough with scar formation and stricture. There is early invasion by bacteria and frequently an apparent permeability to bacteria of an intact intestinal wall.

There is an extensive literature of the clinical aspects of intestinal injuries summarized especially by Flaskamp[11] and Desjardins.[7] The reports of Haendley,[12] Keller,[15] Mühlmann and Meyer,[21] Sanders,[26] Stacy,[29] Ottow,[23] Buie and Malmgren,[3]

Wille,[37] Kleine,[16] Ward,[32] Findley,[9] Robinson,[25] Schmitz,[27] Liebhart and Meisels,[19] and Asherson,[1] describe the generalized injuries from irradiation. Where these involve the intestine there is usually massive destruction and fistula formation. Haendley[12] and Buie and Malmgren[3] discuss injuries to the rectum. Fistulae in particular are studied by Strachan,[30] Counseller and Foor,[6] Smith[28] and Wille.[37] Of present interest are the cases of ulceration included in the reports by Dieterich,[8] Fischer,[10] v.Franqué,[31] Heck,[13] White,[38] and Kolde,[17] and of cicatricial deformity and obstruction by Coulomb and Jean,[5] Bérard and Creyssel,[2] Jones,[14] Collins and Jones,[4] Pemberton[24] and Newell and Crossen.[22] These are the injuries, limited to the intestinal mucosa, which may follow the application of radium and roentgen radiation by modern, finely balanced technique and will, we believe, be frequently reported in the near future.

TECHNIQUE

It is important to know whether these injuries were due to a general overdosage or to some special combination of circumstances. (1) In our series simple overdosage by radium seems to account for the four rectal ulcers. The lesion in this group was in the anterior wall of the rectum (Fig. 1*A*) directly opposite and adjacent to the cervix where there was a heavy concentration of radium. In this region the law of inverse squares must be kept in mind. A thin-walled uterus, a deeply excavated ulcer or a contracted vaginal vault may bring the radium so close to the rectal mucosa as to require a reduction in dosage (Fig. 11). In our cases, however, the uteri were of normal dimensions and in all but one the vaginal vaults were ample. One must conclude that the radium dose was too heavy. This also explains the injury in Case IX where the loop of the sigmoid was adherent to the fundus (Figs. 1*C* and 9). (2) Overdosage by roentgen irradiation probably caused the injury to the small intestines in Cases XI and XII. There was a diffuse involvement of the small intestine in the whole lower abdomen. The large bowel close to the uterus was not particularly damaged, indicating that the radium had caused no special injury. In one of these there was also deep ulceration of the skin (Case XI). (3) The injuries to the rectosigmoid (Fig. 1*B*) lying at some distance from the uterus, on the one hand, and the skin, on the other, are more difficult to explain. The area of the affected intestine was usually small—4 to 8 cm. The gut on either side showed little change. If the condition were due simply to overdosage by radium or roentgen rays, one would expect to find more severe injuries in tissues lying nearer the sources of energy, which was not the case. One may infer that they were caused by crossfiring. Radium rays and beams of roentgen rays entering through various portals, converged on a section of the bowel and brought about, at that point, a greater concentration of energy than at any other point in the pelvis.

The prevention of these injuries will present a difficult problem if we hold to the principle that large total doses are requisite for efficient cancer therapy. Little can be accomplished in the selection of a patient. Idiosyncrasies may exist but are, as yet, not determinable. The specific susceptibility of the intestine should always be kept in mind. Treatment should be modified or stopped if gastrointestinal symptoms are troublesome. Fixation of the intestine in such a way as to hold it in an exposed position through several applications may be a factor. This is unavoidable in the case of rectum and rectosigmoid which are more or less fixed by their anatomical attachments and where adhesions following a previous operation fix the intestine to the uterus. In one of our cases (Case IX) we believe that the sigmoid adhered to the uterus following the first application of radium and was injured by the second. Devices for overcoming these difficulties have not been very efficient. Trendelenburg position, distention of the bowel with water or gas, compression of the abdomen,

etc., will always leave some part of the intestine in contact with the uterus unless there is free fluid in the peritoneal cavity. Instead of relying on such devices it seems wiser to concentrate our efforts on developing an irradiation technique which will exert the most favorable effect upon the cancer and still save the intestine from injury.

Instead of reducing the total milligram-hours and total number of roentgens, we simply lessened the amount of radium and the daily roentgen dose and increased the time of application and have employed the following technique for two years.

In a typical case, 70 mg. of radium (applied as previously indicated) is inserted into the uterus and vagina for 100 continuous hours. Modification in the amount of radium inserted is determined by the estimated distance between the radium and bladder or rectal mucosa. It is reduced if the uterine wall is thin, the vaginal vault contracted or ulceration so deep as to approach a hollow viscus.

Roentgen radiation is given in daily doses of 150–200 r through each of two anterior, two posterior and two lateral or sacrosciatic portals measuring 10×15 cm. Only one field is treated at a sitting. The total for each anterior and posterior field is approximately 2,000 r and for each lateral

TABLE I

A COMPARISON OF TWO CASES; ONE TREATED RAPIDLY AND THE OTHER OVER A PROLONGED PERIOD; THE FORMER SUFFERING SEVERE INJURY, THE LATTER NONE. WHILE THE RADIUM DOSE IS GREATER IN CASE XI, THERE WAS NO IMPORTANT INVOLVEMENT OF THE RECTUM OR SIGMOID. THE EFFECT ON THE SKIN IS OF PARTICULAR INTEREST.

	CASE XI	CASE A
Age, parity	41, para 1, grav. III	53, para III
Weight	131	135
Lesion	Flat, infiltrating, parametrium involved	Cauliflower; parametrium involved
Plan of treatment	Radium before x-ray	X-ray before radium
Radium dose	Uterus 4,000 mg-hr. Vagina 3,000 mg-hr. In 40 hours	Uterus 3,600 mg-hr. Vagina 1,800 mg-hr. In 6 days
Roentgen-ray dose	Distance 50 cm. voltage, 190 kv., filter Cu., 0.55 mm., Al, 1.0 mm., 3 fields, size 15×20 cm.	Same
Duration	18 days	45 days
Exposures	16	30
Daily dose	400 r	300 r
Total	3×2,133⅓ r=6,400 r	3×3,000 r=9,000 r
RESULT		
Lesion	Partial recession (autopsy)	Disappeared after x-ray
Skin	Ulceration	Erythema
Bladder	Negative	Negative
Rectum	Proctitis	Negative
Small intestine	Ulceration, peritonitis	? No symptoms

What the most efficient technique for treating cancer may be, only time will tell. In this clinic we are committed to the policy of giving a maximum radiation dose in one continuous application of radium and a continuous series of roentgen exposures. As described earlier in the article, a total radium dosage of 7,000 mg-hr. and a roentgen dosage of 9,000 to 10,000 r distributed over multiple fields was established. This technique was satisfactory except for these injuries which amounted to 8.7 per cent of the cases treated. It was apparent that the dosage was excessive.

field about 1,000–1,200 r. The grand total is 9,000–10,000 r without back-scattering. The duration of the series is about forty to sixty days. Crossfiring in the center of the pelvis is minimized by directing the rays, during exposure of the anterior and posterior fields, at right angles to the frontal plane. While consideration is paid to the anteroposterior diameter of the abdomen, variation in dosage is determined more by the occurrence of alimentary symptoms and the susceptibility of the skin.

Following the adoption of this technique, there was a striking change in the severity of the symptoms experienced during treatment by both agents, and an apparent cessation of the intestinal injuries (Table 1).

CONCLUSIONS

Cases of injury to the intestines are reported which confirm previous observations on the specific susceptibility of the intestinal mucosa to radiation. Without altering the total dose of milligram-hours, the amount of radium was reduced and the duration of the application prolonged. Without altering the total roentgens, the daily dose and the size of the fields were reduced. The number of treatments and the total duration of the series were increased. Following these alterations in technique, the injuries have apparently ceased.

CASE REPORTS

Ulcer of the Rectum

CASE 1. L. S., aged thirty-four, a virgin; weight 151½ lb.; adenocarcinoma of cervix, League of Nations Stage 1. Radium, 100 mg. in uterus, forty hours (4,000 mg-hr.). Seven days later 75 mg. in vagina for forty hours (3,000 mg-hr.). Twenty-one days later roentgen therapy applied over six pelvic portals (two anterior, two posterior and two lateral fields, each 10×15 cm.). Daily dose 250 r, later reduced to 100 r. Grand total 7,000 mg-hr. and 7,000 r in seventy-one days. During treatment patient was frequently nauseated and complained of diarrhea which was aggravated when roentgen rays were applied to the left lower quadrant. Slight urinary frequency for four weeks after treatment. Six and a half months after beginning treatment and five months after the end of treatment she had abrupt onset of diarrhea, bloody stools, painful defecation. Examination showed an ulcer 4 cm. long, 1 cm. wide and 0.5 cm. deep beginning about 6 cm. from the anus. Surrounding this was an induration 7×5 cm. in extent and about 2 cm. thick. Roentgen examination by means of barium enema showed a spasm of the distal portion of the rectum. The remainder of the colon was normal. The cervix and vagina were red. No slough. Bloody stools persisted for eight weeks. Vague moderate pelvic pain for three months. Examination fifteen months after treatment showed an induration 3×5 cm. There was a stellate scar at the site of the ulcer. The roentgen examination revealed no organic lesion or spasm.

Ulcer of the Rectum

CASE II. D. S., aged twenty-nine, para II; weight 115 lb., squamous carcinoma of cervix, League of Nations Stage 1. Radium, 75 mg. in uterus and 75 mg. in vagina for forty-five hours (6,750 mg-hr.); eight days later roentgen therapy, one anterior portal 15 × 15 cm. and two posterior portals 10 × 10 cm., 33 treatments in thirty-eight days. Daily dose 100–250 r; total 6,450 r; grand total 6,750 mg-hr. and 6,450 r in forty-six days. Symptoms and physical signs the same as Case 1 except that proctoscopy showed a constriction of the lower sigmoid colon. Slight discomfort at stool persisted twenty-four months. A roentgen examination of the colon eight and a half months after beginning of treatment and seven months after the end of treatment disclosed a spastic rectum and sigmoid. There were no changes in the mucosal pattern. A second examination fourteen months later showed a constriction at the rectosigmoidal junction, 11 cm. from the anus. This constriction was fairly smooth and the lumen of the affected area showed very little expansion.

Ulcer of the Rectum

CASE III. A. E., aged fifty-three; weight 144 lb.; para 1, squamous carcinoma of cervix, League of Nations Stage II. Radium, 100 mg. in uterus and 75 mg. in vagina for forty hours (7,000 mg-hr.); thirty-seven days later roentgen therapy through one anterior and two posterior portals 20 × 20 cm., 24 treatments in forty-six days. Daily dose 60–75 r over each of the three fields. Total 5,400 r. After three months a similar series of roentgen treatments. Grand

total 7,000 mg-hr. and 10,800 r in one year seven months. Twenty-one months after first treatment and two months after the end of treatment, abdominal cramps, constipation, scant stools with blood clots. Examination showed a small ulcer on the anterior wall of rectum 5 cm. from the anus, surrounded by induration 3 cm. in diameter. Duration of symptoms five weeks. Induration in rectal wall disappeared after one year. Since then symptom-free (five years).

Ulcer of the Rectum

Case iv. E. T., aged thirty-one; weight 124 lb.; squamous carcinoma of cervix, League of Nations Stage ii. Radium, 2,400 mg-hr. in uterus. Eight days later 2,400 mg-hr. against cervix. Four months later 2,000 mg-hr. in vagina. Six months later 100 mg-hr. in vagina. Total 7,800 mg-hr. in ten months. Roentgen therapy two months later, one anterior and one posterior portal 20 × 20 cm.; 16 treatments in sixty-eight days. Daily dose 150 r. Total 2,400 r. After six and a half months, 8 treatments in twenty days, total 1,200 r; after nine months, 8 treatments in seventeen days, total 1,200 r and two and a half months later 13 treatments (three fields per each treatment) in eighteen days, total 4,500 r. Grand total 7,800 mg-hr. and 9,300 r in one year ten months. Rectal tenesmus and an induration 6 cm. from the anus in the anterior rectal wall was observed three months before the last radium treatment. Slight discomfort at stool for one year. Stools became lightly streaked with blood one year after beginning treatment and persisted for six years. Induration still present after eleven years. It is about 3 cm. in diameter and of the consistence of soft rubber. In the center is a small puckered scar.

Ulcer of the Rectosigmoid

Case v. M. H., aged forty-four; weight 130 lb., grav. 1; squamous carcinoma of cervix, League of Nations Stage iii. Radium, 100 mg. in uterus for forty hours (4,000 mg-hr.); twelve days later roentgen therapy, one anterior portal 15 × 20 cm., two posterior portals 15 × 15 cm., 24 treatments in thirty-one days. Daily dose 250 r. Total 5,700 r. Twenty days later radium 50 mg. in cervix and 50 mg. in vagina for forty hours, 4,000 mg-hr. Fourteen days later, roentgen therapy, one right anterior portal 10 × 10 cm. and one right posterior portal 15 × 15 cm.; 10 treatments in fourteen days. Daily dose 200 r. Total 2,000 r. Grand total 8,000 mg-hr. and 7,700 r in ninety days. Eight months after beginning treatment and five months after end of treatment, abdominal cramps and bloody stools which persisted for seven months. A barium enema six months after end of treatment showed the outline of the colon to be normal except for the presence of a slight spasm of the proximal sigmoid. A second examination (Fig. 2) six months later showed a persistent constriction in the pelvic sigmoid causing a complete obstruction to the flow of the barium. A roentgenogram taken after an attempted evacuation of the barium showed none of the barium proximal to the constriction to be expelled. A third examination five months later showed thd lumen of the sigmoid to be smoother. The narrowing of the lumen was not as marked as before. A fourth

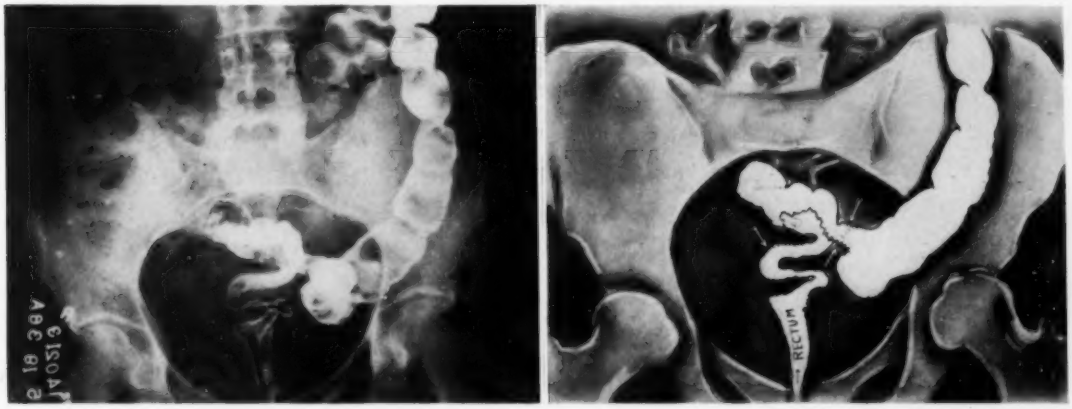

Fig. 2. Case v. The sigmoid colon shows moderate spasm and narrowing of its lumen. Note the serrated outline and exaggerated mucosal folds (May 19, 1936).

examination (Fig. 3) seven months later revealed the narrow portion of the sigmoid to expand under pressure but as soon as the pressure was relieved the lumen became slightly narrower than normal. Patient is well three years.

Ulcer of the Rectosigmoid

CASE VI. M. D., aged fifty-six, weight 122 lb., grav. II; squamous carcinoma of cervix, League of Nations Stage II. Radium, 100 mg. in uterus and 50 mg. in vagina for thirty-six hours. Sixty-eight days later roentgen therapy, one anterior portal 20×20 cm. and two posterior portals 15×20 cm.; 18 treatments in thirty days. Daily dose 60–75 r over each of the three fields. Total 4,500 r. Five months later, 21 treatments in thirty-four days. Total 4,500 r. Grand total 5,400 mg-hr. and 9,000 r in nine months. Twenty months after beginning of treatment and eleven months after end of treatment she complained of abdominal cramps, constipation and bloody stools suggesting partial intestinal obstruction. Barium enema (Fig. 4) showed a persistent spasm and constriction in the region of the upper rectum and lower sigmoid. The mucosal pattern in the affected area appeared exaggerated but not destroyed. A second examination two and a half months later, after the oral ingestion of the barium meal, showed the terminal ileal loops to be spastic and irregular. A laparotomy revealed the rectosigmoid and some of the coils of the ileum firmly bound to the sacrum. No adhesions about uterus. Sigmoid for about 4 cm. and loop of ileum for 2 cm. were gangrenous. Colostomy. Mikulicz tampon in pelvis. Death nine weeks postoperative. Specimen of sigmoid showed necrosis through entire wall.

Ulcer of the Rectosigmoid

CASE VII. C. S., aged sixty-eight; weight 94 lb.; para 1, squamous carcinoma of cervix, League of Nations Stage I. Radium, 100 mg. in cervix and uterus and 50 mg. in vagina for forty hours (6,000 mg-hr.). Forty days later roentgen therapy, one anterior portal 15×15 cm. and one posterior portal 10×15 cm.; 26 treatments in sixty days. Daily dose 200–100 r. Total 4,000 r. Because of considerable nausea and diarrhea, roentgen therapy was curtailed. Five months after beginning treatment and two months after end of treatment abdominal pain, constipation, bloody stools. Examination showed obstruction 7 cm. from anus. Operation: uterus free of adhesions to sigmoid. Wall of rectosigmoid thickened for 4 cm. Colostomy, cholecystectomy. Death sixth day postoperative. Pneumonia. Autopsy findings confirmed those of operation except for more adhesions. Annular ulcer in rectosigmoid, 3 cm. long. The

FIG. 3. Case V. One year later (May 27, 1937). The walls of sigmoid smoother. Narrow portion is now limited to a segment (see arrow). The lumen expands under pressure, but mucosal fold still exaggerated.

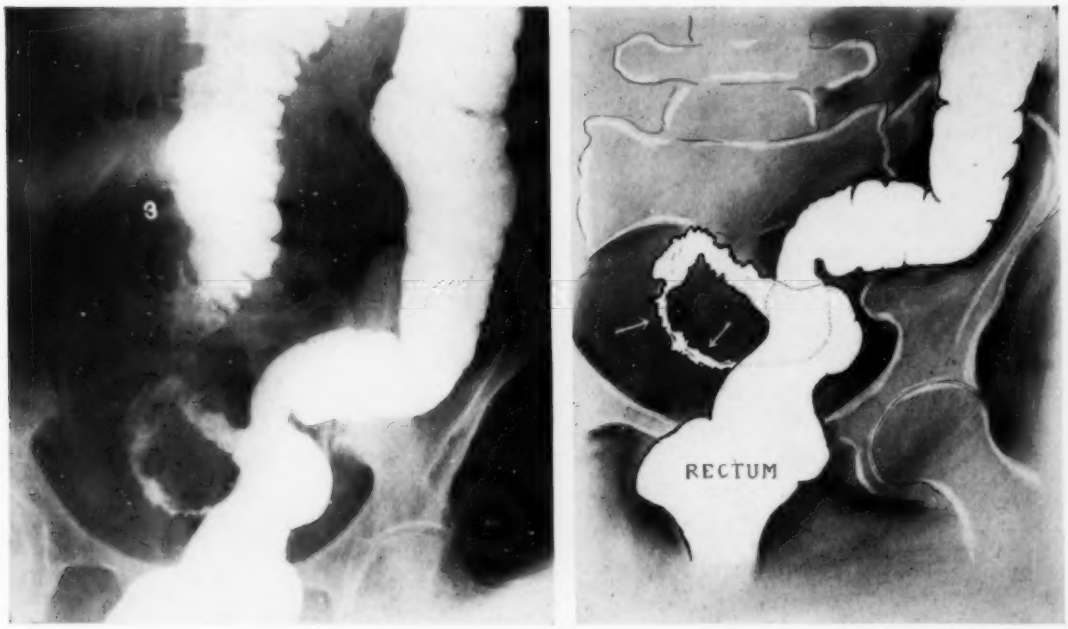

Fig. 4. Case vi. Note the persistent spasm and constriction in upper rectum and distal sigmoid. The mucosal pattern appears exaggerated.

base was ragged, gray, the edge slightly elevated, sharply demarcated. Microscopic examination showed necrosis, limited to the mucosa. There was no trace of carcinoma. The submucosa and inner layer of the muscularis showed slight cloudiness of the cells and a marked infiltration by polymorphonuclear leukocytes and plasma cells and moderate growth of scar tissue.

Ulcer of the Rectosigmoid

Case viii. A. K., aged forty-nine; weight 138½ lb., para 1. The clinical picture was almost identical with Case v. Radium, 100 mg. in uterus, 75 mg. in vagina for forty hours (7,000 mg-hr.). Thirty days later roentgen therapy, two anterior and two posterior portals 10 × 15 cm. each; 32 treatments in forty-three days. Daily dose 300 r, later 200 r. Total 8,400 r. Grand total 7,000 mg-hr. and 8,400 r in seventy-three days. Barium enema (Fig. 5), nine months after beginning treatment and six months after treatment, filled the rectum and flowed as far as the distal portion of the sigmoid colon, just proximal to the rectosigmoidal junction where there was a delay in the passage of the barium.

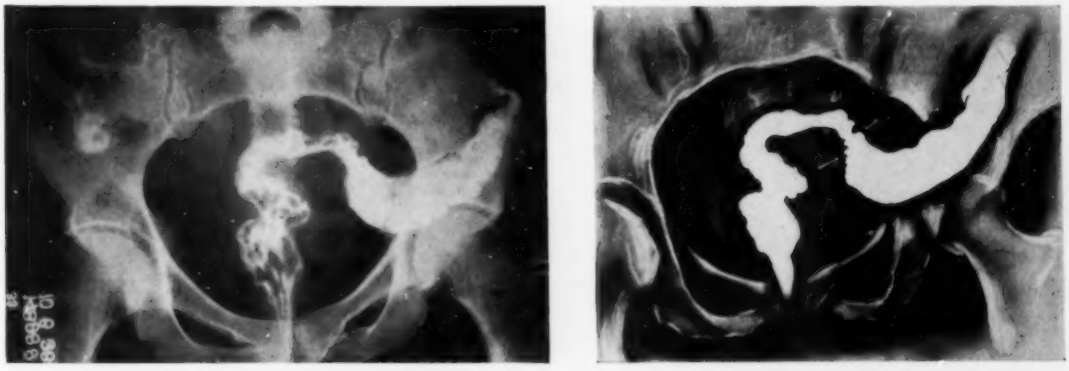

Fig. 5. Case viii. Persistent spasm at the junction of the descending colon and sigmoid with accentuated mucosal folds (July 30, 1936). Second examination ten months later showed persistence of exaggerated folds. No spasm or stricture found (May 21, 1937).

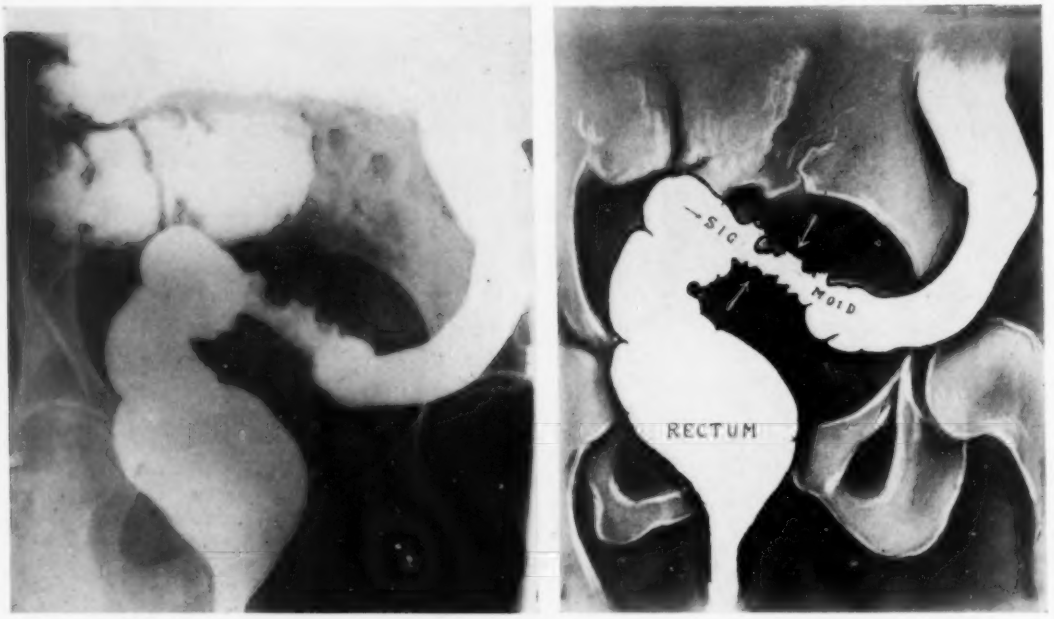

FIG. 6. Case IX. Note the persistent narrowing of the proximal sigmoid, with serrated outline. The mucosal folds are hypertrophic (edema). It is difficult to differentiate it from an annular carcinoma.

The lumen of the sigmoid appeared narrowed and fixed. The mucosal folds appeared exaggerated. Another barium enema three months later showed the previously described constriction of the sigmoid to be persistent but somewhat less marked both as to length and encroachment on the lumen. A third examination seven months later, nineteen months after beginning treatment, showed the barium to fill the colon without encountering any stricture or

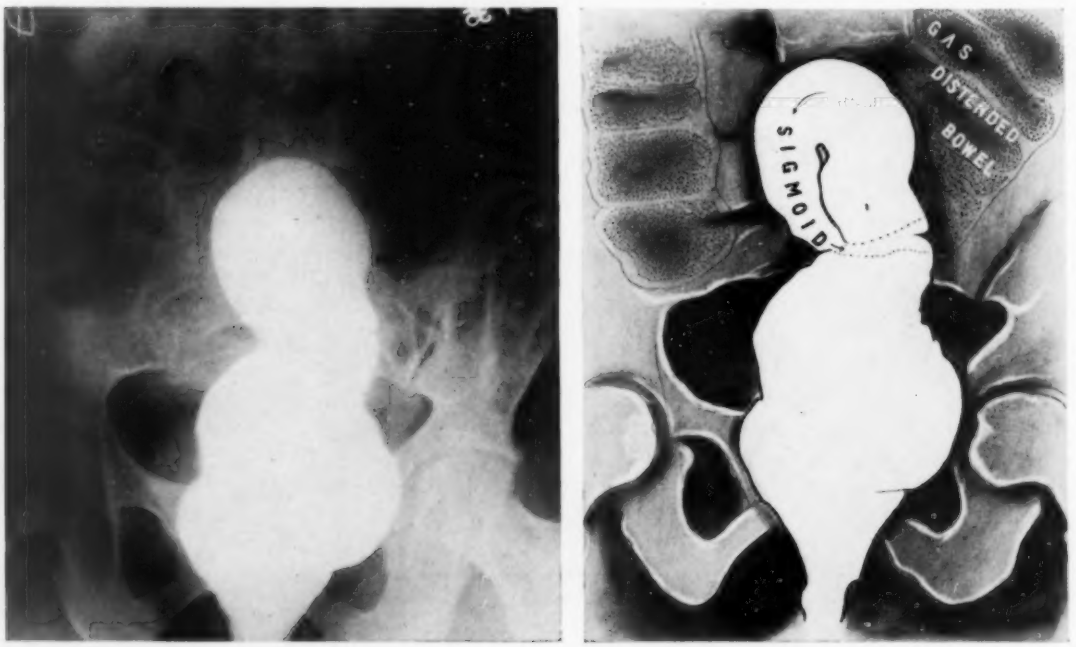

FIG. 7. Case X. Note the obstructive lesion where the sigmoid loop curves downward. The colon proximal to the constriction is distended with gas.

obstruction. The only residual finding was slightly exaggerated mucosal folds.

Ulcer in the Loop of Sigmoid

Case IX. C. L., aged fifty-seven; weight 123 lb., para II, adenocarcinoma of corpus, League of Nations Stage I. Radium in uterus 100 mg. for thirty hours (3,000 mg-hr.); thirty-five days later 112 mg. in uterus for twenty-four hours (2,700 mg-hr.). Nineteen days later, roentgen therapy through two anterior fields 10×10 cm. and two posterior fields 10×15 cm.; 52 treatments in sixty-three days. Daily dose 100 r. Total 9,200 r. Grand total 5,700 mg-hr. and 9,200 r in 110 days. Eight months after beginning treatment and four months after end of treatment, diarrhea, bloody stool, signs of partial obstruction. Two repeated barium enemas (Fig. 6) four months and five months after end of treatment showed a persistent narrowing of the proximal sigmoid with marked serration of the outline and exaggeration of the mucosal folds at the site of the constriction. In view of the absence of any evidence of destruction of the mucosa, a neoplasm was not suspected. At operation a section of the loop of sigmoid 5 cm. long was bound to bladder and rectum by fibrinous adhesions. It was narrowed and indurated. The surface was deeply injected and marked with numerous dilated vessels (Fig. 9). Colostomy. Recovery. Well twenty-four months.

Ulcer in Loop of Sigmoid

Case X. E. M., aged forty-one; weight 208 lb.; grav. II, squamous carcinoma of cervix, League of Nations Stage I. Radium 100 mg. in uterus for twenty-three and one half hours (2,350 mg-hr.); twenty days later, roentgen therapy one anterior portal 15×20 cm., two posterior 15×15 cm.; 21 treatments in thirty days. Daily dose 200 r. Total 4,200 r. Five days later, radium 100 mg. in uterus and 75 mg. in vagina for thirty-six hours (6,300 mg-hr.); nineteen days later, roentgen therapy, two anterior portals 15×15 cm. and two posterior portals 15×15 cm.; 18 treatments in twenty-two days. Daily dose 200 r. Total 3,600 r. Grand total 8,650 mg-hr. and 7,800 r in ninety-seven days. Eight months after beginning and five months after end of treatment, abdominal cramps, bloody stools, vomiting, obstruction. A barium enema (Fig. 7) five months after end of treatment showed an obstructive lesion at a point where the sigmoid loop curves downward and behind its first portion. The colon proximal

Fig. 8. Case XV. A persistent narrowing of the midportion of the sigmoid. Note distention of the colon proximal to the narrowed loop. Mucosal folds exaggerated (edema).

to the apparent constriction appeared greatly distended by gas. Operation. Many adhesions about sigmoid, omentum and coils of small intestine. Constriction high in sigmoid. Exact relationship to uterus not determined. Colostomy. Sudden hemorrhage from colostomy wound three months postoperative. Death. No autopsy.

r. Grand total 7,000 mg-hr. and 6,400 r in thirty-nine days. Toward the end of roentgen therapy, nausea, vomiting, diarrhea and anemia. Skin of buttock ulcerated ten days after treatment was ended. Signs of chronic peritonitis; a diffuse dough-like rigidity and slight tenderness in lower portion. Death two months after treatment. Autopsy. Fibrinopurulent peritonitis.

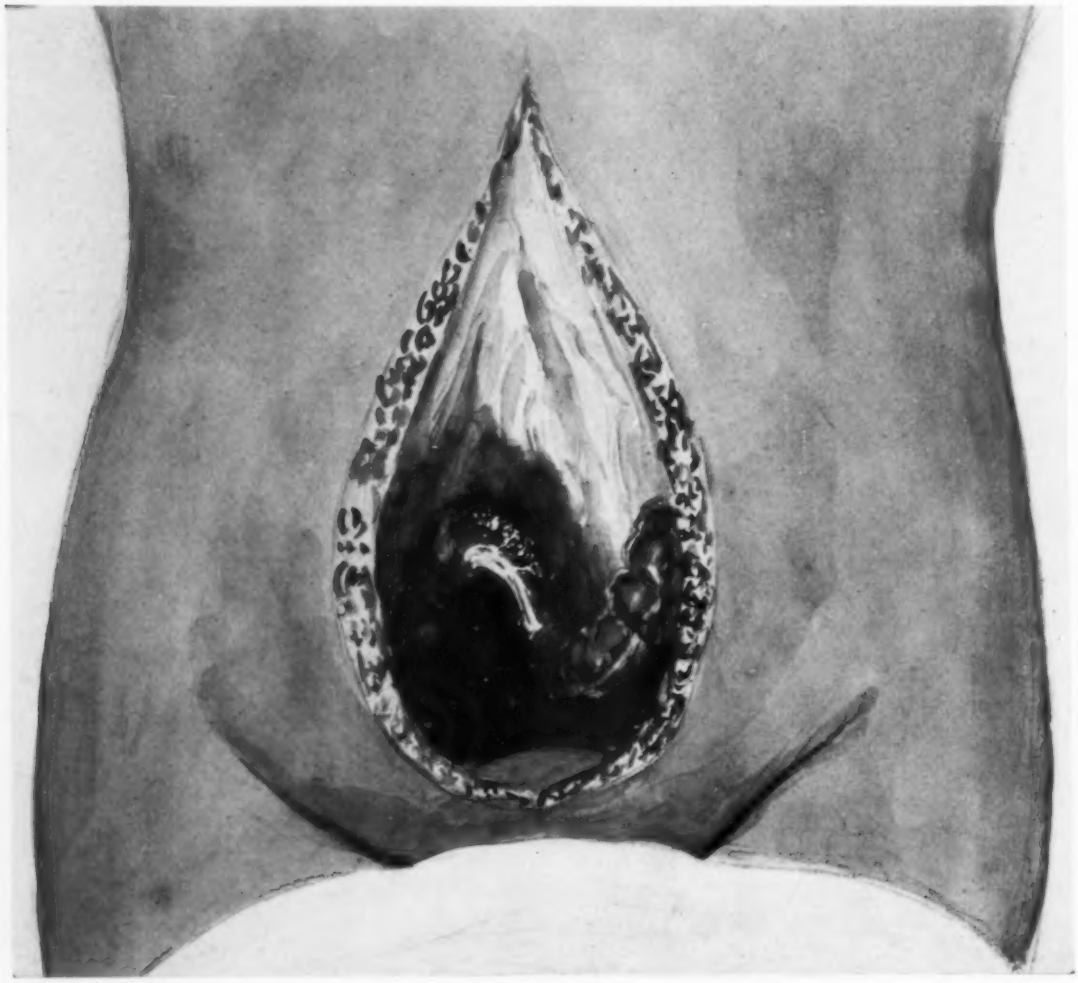

FIG. 9. Case IX. Water color of the sigmoid, showing fibrin and engorged blood vessels and the constriction.

Ulceration of Small Intestine

CASE XI. A. F., aged forty-one; weight 131 lb.; para 1, grav. III; squamous carcinoma of cervix, League of Nations Stage III (see Table 1). Radium, 100 mg. in uterus, 75 mg. in vagina for forty hours (7,000 mg-hr.); twenty-one days later roentgen therapy, three fields 15×20 cm., one anterior and two posterior; 16 treatments in seventeen days. Daily dose 400 r. Total 6,400

Adhesions between abdominal wall and intestines and between coils of intestine. Intestinal walls friable, gray, edematous. Mucous membrane of ileum thick, hemorrhagic. Many small ulcers. Microscopically: destruction of epithelium save in the depths of the crypts (Fig. 10). Submucosa edematous and infiltrated with lymphocytes, plasma cells, scattered polymorphonuclear leukocytes and eosinophiles. Mus-

cularis normal. The peritoneal surface of the uterus showed inflammation. Myometrium normal. Cervix, slight necrosis; some islands of carcinoma persisted.

Ulceration of Small Intestine

Case xii. V. S., aged forty-four; weight 120 lb.; para 1. Squamous carcinoma of cervix, League of Nations Stage 1. Radium, 100 mg. in uterus and cervix for thirty-six hours (3,600 mg-hr.). Sixteen days later 123 mc. in vagina for 24.4 hours (3,000 mc-hr.); fifteen days after last radium, roentgen therapy—three portals, one anterior 20×20 cm., two posterior 15×20 cm.; 18 treatments in twenty-nine days. Daily dose 180–450 r. Total 4,500 r repeated after two months. Eighteen treatments in thirty days. Total 4,500 r. Grand total 6,600 mg-hr. and 9,000 r in 163 days. Seven and a half months after beginning treatment, two months after last roentgen therapy, abdominal pain, signs of partial intestinal obstruction. Operation: fibrinopurulent peritonitis. In lower abdomen multiple adhesions between intestines and between uterus and sigmoid. The intestines "appeared rather bloodless." No specimens. Death eight weeks later after gradual downhill course.

Obstruction of Small Intestine

Case xiii. E. B., aged fifty-one; weight 174 lb.; para 1. Squamous carcinoma of cervix, League of Nations Stage iii. Radium, 100 mg. for forty hours in uterus; twenty-six days later 100 mg. radium for twenty-four hours against crater in cervix. Total 6,400 mg-hr. in twenty-six days. No roentgen therapy given. Considerable dysuria. Four months after beginning treatment and three months after end of treatment signs of partial intestinal obstruction. Operation: loop of ileum, apparently intact, caught behind a pelvic inflammatory mass involving uterus and parametrium. Ileostomy. Two months later, colostomy. Well six years.

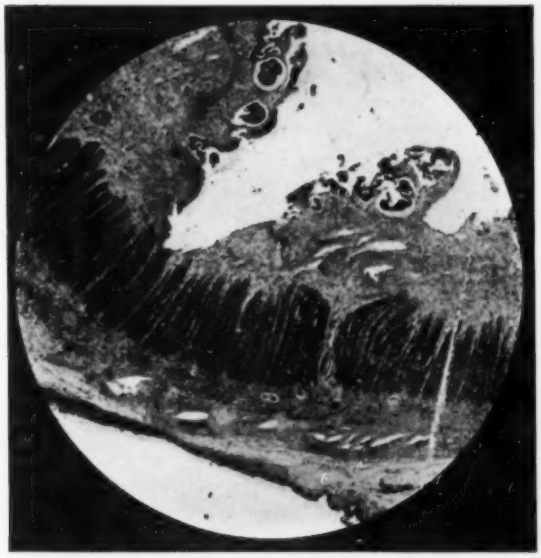

Fig. 10. Case xi. Photomicrograph of small intestine, showing extensive injury to the mucosa and little to the muscularis.

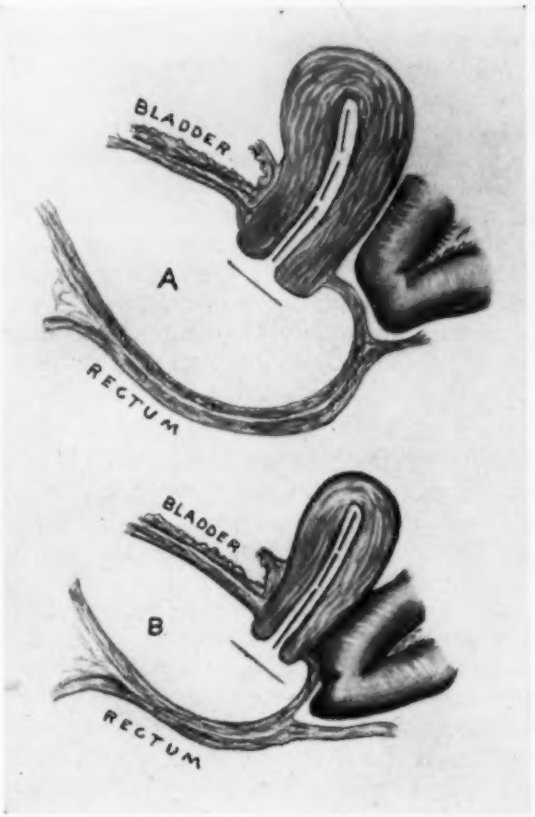

Fig. 11. Diagram to illustrate the importance of estimating distances in intrauterine and vaginal radium application. The distances between radium and intestine in the upper figure are double those in the lower. If the radium dose is the same in both cases, the bowel in *B* will receive roughly four times as much radiation as in *A*.

Case xiv. K. R., aged forty-six; weight 225 lb.; para 1. Squamous carcinoma of cervix, League of Nations Stage 1. Radium, 100 mg. in uterus for forty-four hours (4,400 mg-hr.); eight days later 75 mg. in vagina for forty-four hours (3,300 mg-hr.); fifty-six days later roent-

gen therapy, one anterior and two posterior portals 20×20 cm.; 18 treatments in thirty-six days. Daily dose 60–150 r (over 3 fields per each treatment according to "saturation" method of Pfahler). Total 4,500 r. Sixty three days later, 19 treatments in thirty-three days. Total 4,500 r. Two and a half years later, 25 mg. in vagina for thirty hours (750 mg-hr.). Grand total 8,450 mg-hr. and 9,000 r in three years and two months. Three and a half years after beginning and four months after end of treatment, symptoms of obstruction. Physical examination, frozen pelvis. No sign of ulceration in intestines. Death. No autopsy.

CASE XV. M. L., aged forty; weight 159 lb.; para II. Squamous carcinoma of cervix, League of Nations Stage I. Pregnancy six weeks. Biopsy of cervix. Roentgen therapy, one anterior portal 15×20 cm. and two posterior 15×15 cm.; 24 treatments in twenty-eight days. Daily dose 250 r. Total 6,000 r. Complete spontaneous abortion seventeen days after beginning and eleven days before ending roentgen therapy. Five days after roentgen therapy and sixteen days after abortion, radium 100 mg. in uterus and cervix for forty hours (4,000 mg-hr.); eighty days later, radium 50 mg. in cervix and 50 mg. in vagina for forty hours (4,000 mg-hr.). One year seven months later, two anterior portals 10×15 cm., 20 treatments in thirty-two days. Daily dose 200 r. Total 400 r. Seventeen days later, two lateral portals 15×20 cm., four treatments in seven days. Daily dose 250 r. Total 1,000 r. Grand total, 8,000 mg-hr. and 11,000 r in two years. Two years after beginning and immediately after ending treatment, symptoms of irritation, then pain and bleeding from rectum and bladder. Physical examination: frozen pelvis. Barium enema (Fig. 8) one month after end of treatment, showed a persistent narrowing of the lumen of the distal sigmoid which was approximately 6 cm. long situated in its middle portion. The outline of the sigmoid showed exaggerated mucosal folds. Death two years four months after beginning treatment. No autopsy.

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DISCUSSION ON PAPERS OF DRS. SCHMITZ, PHANEUF, FRAZELL, SMITH, CORSCADEN, KASABACH AND LENZ

DR. WILLIAM P. HEALY, New York. Dr. Schmitz has given us a splendid talk on uterine myomata. I had to discuss this subject recently and I went over a series of 216 cases of myomata that passed through my office during the preceding two years. To a fair degree Dr. Schmitz and I agree in our reactions to myomata. In my group 9 per cent of the tumors were identified as part of the routine pelvic examination and needed nothing further than recognition on the part of the physician and the knowledge on the part of the patient that she had a tumor. Only 4 per cent of the cases were of the type in which I thought curettage for diagnostic purposes and roentgen therapy would be satisfactory rather than radium. More patients under my care are treated with curettage and radium than with curettage and roentgen therapy. In some of the large tumors I think it is well to combine radium and roentgen therapy to bring about ovarian castration. If we do not bring about castration the bleeding will return. If, after castration, bleeding begins again, there is, in all probability, a submucous myoma that will require surgical removal; 67 per cent of the cases were in the surgical group and myomectomy was done in 10 per cent of this group. If the patient is young enough I think this should be done. In the remainder subtotal or panhysterectomy was the surgical procedure. So far as my experience goes, I think 2 out of 3 of the cases of fibromyoma

present indications for surgical treatment rather than irradiation.

With regard to Dr. Phaneuf's paper, we at Memorial Hospital feel that cases of carcinoma of the corpus can be divided histologically into two large groups—one the adenoma malignum group which constitutes about 50 per cent. If we are certain that this is the type of carcinoma the patient has we do not use irradiation for we know these cases, if surgically operable, are cured by hysterectomy. Many of them are not operable and we have to treat those with irradiation. Since we cannot be certain of the histologic type, we invariably do a diagnostic curettage and insert radium in the uterus. If the pathologist reports adenocarcinoma we follow this with roentgen therapy. If the case is surgically operable we do a panhysterectomy, six or eight weeks later. About 50 per cent of the cases of carcinoma of the corpus are adenocarcinomata. Such cases are curable to only a small degree by hysterectomy alone, about 10 to 15 per cent. Therefore, we use irradiation, first with intrauterine radium and then with the roentgen ray, and operate later. We are inclined to believe that this plan of using preoperative irradiation is bringing about improvement and that we will salvage more cases of carcinoma of the corpus.

In the last five-year series there were 31 cases but only 22 were primary. The other 9 were recurrent, treated elsewhere by radium or operation, or both, and then sent to us with recurrence of the disease and none of the 9 cases survived five years. In the primary cases, 77.5 per cent have passed the five-year period. We now have 17 cases of that group alive.

Of our 22 primary cases, 12 were bad risks and were treated with irradiation only. The average age was sixty-four years and some were over seventy. Despite this advanced age 7 of the 12 are still alive. Two of the 5 who are dead died of carcinoma. Two others died from cardiac disease and one as the result of a railroad accident.

In the cases of hysterectomy after irradiation we have a remarkable situation in having them all alive, but mark their average age when treated, fifty-four years instead of sixty-four. This indicates the way in which I think these cases can be selected. All these patients I know are well and free from any evidence of active disease. Two patients were treated by hysterectomy alone.

The average age of these patients was forty-five. Both of them had large uterine myomata and both had hysterectomies without diagnostic curettage. In each we did what always should be done in any supracervical hysterectomy. The uterus on removal must be at once split so that one can make an inspection of the interior. In this instance it was found in each case that there was in the upper portion of the corpus near the fundus a small area of carcinoma which had not been suspected. Therefore a complete hysterectomy was done. Fortunately the tumor was of the adenoma maligmum type so they were cured.

Dr. Corscaden's paper is of great interest to all of us. In this slide you will see two large areas of necrosis in this small bowel which I resected. The necrosis involved all the structures from the serosa inward. We have had 6 cases that I recall of bowel injury, 3 in the terminal ileum and 3 in the rectosigmoid region. All but 2 have been explored by me surgically. Two of the operated cases are alive and well more than five years since operation.

As to the points that were made by Dr. Corscaden regarding the duration of treatment as a factor in the cases of bowel injury, our patients in the series of 6 injuries have been treated by different methods roentgenologically.

I am of the opinion that when these lesions occur in the intestine, in the majority of instances, we have one of two things present preceding the irradiation, either a local colitis or enteritis and an area of lowered resistance, or superficial ulcers, or if the lesion has occurred in the rectum or rectosigmoid region near the cervix there probably was an adhesion of the bowel to the posterior uterine wall that kept it fixed during the period of treatment. From that proctitis occurred with infection. I think radiation necrosis is a combination always of infection plus radiation damage.

DR. ANGUS K. WILSON, Elkins, W. Va. I wish to confine my discussion to the paper by Drs. Corscaden, Lenz and Kasabach. In a relatively small number of cases of cancer of the cervix, we have noted signs and symptoms of intestinal damage, probably due to irradiation, in five. Treatment was by a combination of radium and roentgen therapy.

Case 1 was a patient, aged fifty-nine, who was first seen in December, 1935, with a very early carcinoma of the cervix. Her treatment consisted of roentgen therapy, a total of 1,800 r, including back-scatter,

being delivered to six pelvic fields, the factors being 200 kv. (peak), 10 ma., fields 10×10 cm., 80 cm. distance, Thoraeus filter, 5.8 r per minute, 300 r per treatment. During the first twelve days she received treatment over only one area; thereafter, for the remaining fifteen days of treatment, two areas were treated each day. She had no symptoms of gastrointestinal upset following roentgen therapy. Radium treatment was divided into two parts, the first course being started two weeks following completion of roentgen therapy. At this time she received 4,000 mg-hr. by intrauterine tandem containing 50 mg. of radium, filtered through 1 mm. platinum and 1,600 mg-hr. in eighty hours by colpostat, containing 20 mg. of radium. Six weeks later she received a further 1,300 mg-hr., in twenty-six hours, by intrauterine tandem, and 1,980 mg-hr., in sixty-six hours, by colpostat, giving a total of 8,800 mg-hr. by radium in two courses spread over almost two months.

She subsequently developed severe proctitis, with bleeding and partial obstruction. Later we were able to demonstrate that she had a recto-uterine fistula. Bullous edema of the bladder, with marked cystitis and hematuria, was very troublesome. At first, the bladder condition resembled very closely extension of carcinoma to that organ. This is the only case in which we were able to demonstrate bladder changes other than those of inflammatory nature. Under expectant treatment she gradually recovered and when seen a week ago, fifteen months after commencement of treatment, her bladder was normal and there were no signs of malignancy.

Case II, aged forty-nine, was admitted in March, 1936, with advanced carcinoma of the cervix which involved the parametria. She received 300 r to each of six pelvic fields, the same factors as in the previous case being used. Treatment was given twice daily, two areas receiving 300 r at each session, and occupying one month. She likewise presented no signs or symptoms of intestinal damage and one month after completion of roentgen therapy, radium therapy was instituted. Treatment in this case likewise was divided into two parts. In the first course she received 3,500 mg-hr. by intrauterine tandem (50 mg. filtered through 1 mm. platinum), in seventy hours and 1,750 mg-hr. by colpostat, containing 30 mg. of radium filtered through 1 mm. platinum. One month later vaginal radium therapy was completed by repeating the dose previously given by vaginal colpostat. She thus received a total of 7,000 mg-hr. radium therapy and 18,000 r (including back-scatter), by roentgen irradiation during the course of three months. Symptoms referable to the intestinal tract were less marked in her case and while definite improvement occurred, the patient never became free of disease and died seven months after being first observed.

Case III was a woman, aged forty-nine, who had squamous carcinoma occupying the cervical canal and invading the cervix. There was no demonstrable involvement of the parametria. Her treatment consisted in roentgen therapy, given in the same manner as in Case II, with a total of 3,000 r to each of six areas in one month. The patient showed no clinical evidence of intestinal radiation effect and returned five weeks following completion of the roentgen treatment for radium therapy. Treatment in her case likewise was divided into two parts. The first consisted of 1,200 mg-hr. by colpostat containing 20 mg. of radium and 3,000 mg-hr. by intrauterine tandem containing 50 mg. of radium. Following this treatment she showed no evidence of intestinal upset. One month after completion of the first course, the second course of radium therapy was given and consisted of 1,800 mg-hr. by colpostat, containing 30 mg. of radium. She thus received a total of 6,000 mg-hr. in sixty hours (intrauterine), and 120 hours per vagina. Two months following completion of the radium treatment, the patient first complained of abdominal pains referable to the sigmoid colon, and rectum. Her symptoms consisted of tenesmus and increasingly obstinate constipation. A roentgenogram showed an almost complete stenosis of the large bowel just above the sigmoid flexure. In the region of the stenosis the bowel was firmly fixed, while above and below it was movable. At subsequent operation for relief of obstruction, she was found to have massive adhesions throughout the pelvic region. Inadvertently a large sac, containing pus, was ruptured and it was impossible to perform a colostomy. Her symptoms, while relieved, did not entirely disappear and although she drained fecal matter through the abdominal wound adequate bowel evacuation was never possible. She died six weeks after operation but we were unable to obtain permission to perform an autopsy.

Case IV was a patient admitted in March of this year. She received elsewhere a massive radium bomb treatment, consisting of 2,000 mg-hr., delivered in one and a half hours for a large, fungating carcinoma, the size of a silver dollar on the anterior lip of the cervix. This treatment was given in January and two months later, in March, she was referred to us for roentgen therapy to the parametria. Treatment was outlined on the same plan as in the previous cases here presented, but it was impossible to complete the course owing to the rapid development of nausea, vomiting, and intestinal upset. She received only 1,200 r to each of six areas, using the following factors: 200 kv. (peak), 15 ma., filter 10×10 cm., 60 cm. distance, Thoraeus filter, 20 r per minute, two areas treated daily. Adequate investigative work was not done in this case since the patient insisted on going home and has declined to cooperate in follow-up. A communication from her family doctor one month after completion of treatment was to the effect that her intestinal symptoms were less marked than previously, and that constipation—which was becoming increasingly obstinate upon completion of

treatment—was definitely less. It is probable that she would have shown much greater disturbance had further treatment been given.

Case v, aged thirty-eight, was admitted in February, 1937; she had a huge, cauliflower-like mass involving the entire vault of the vagina. In this case radium treatment was administered first and consisted in 3,000 mg-hr. by vaginal colpostat, it being impossible to visualize the cervical canal. Intrauterine treatment was postponed until she received 1,200 r to each of the six pelvic fields in the same manner as Case IV, in twenty days. By then the canal could be visualized and she received intrauterine treatment by tandem, as in previous cases, for a total of 3,500 mg-hr. Four days following removal of the intrauterine radium, roentgen therapy was recommenced, but she could tolerate only 1,500 r to each field. Rectal tenesmus was troublesome but not particularly severe, and she had no special trouble from constipation or other signs of obstruction. When seen two months later she was locally free of disease and there was no evidence of intestinal obstruction, though very slight narrowing at the junction of the descending and sigmoid colon was present.

In our previous experience where only radium was used, these more or less severe intestinal symptoms did not develop. While it is entirely possible that treatment was, by either or both roentgen rays and radium, given in too concentrated a form, similar upsets have not been observed where the same dosage of either roentgen rays or radium was used. In our opinion it appears highly probable that where the two agents are to be combined a different pattern of treatment must be employed. It may be that, by extending the interval between courses of treatment or by administering smaller doses of roentgen radiation at each treatment, or by lengthening the time of radium treatment, these accidents may be avoided.

The paper presented has opened up a field of investigation which has been too much neglected and it is our hope that today's discussion will bring forth further comment regarding the complications attending treatment of cervical cancer, so that those of us who see relatively few cases may profit by the experience of those with more extensive material.

DR. B. F. SCHREINER, Buffalo, N. Y. I have been absent from these meetings for about four years and feel well repaid for coming today in listening to the papers presented. I thoroughly enjoyed Dr. Schmitz, whose papers are always instructive and very scholarly. Dr. Healy's discussion covered the essential parts of Dr. Schmitz' paper, so there is little left to add.

Dr. Phaneuf's paper was instructive and Dr. Healy's discussion coincides very much with our views. I wish to add that with purely radiologic methods, our results for corpus carcinoma have been 43 per cent five-year healings.

Of particular interest to me was Dr. Frazell's work in estimating the amount of radiation the tumors received. It was almost a duplicate of our own cases, except that we had 62 per cent five-year healings in Group I (Schmitz), in Group II about 31.5 per cent and in Group III about 17 per cent. It is exceptional that one case falling in Group V is well five years. Our figures show only 1.5 per cent.

Dr. Smith's paper brought out the important factor that a large percentage of cases referred to a tumor clinic are very far advanced; that palliative treatment is all that one can hope for. In our clinic, about 70 per cent fall into this group. I think each of us can recall cases which seemed hopeless, but after palliative measures, we were suprised by having patients live five or more years. I recall one patient with carcinoma of the ovary who was explored and nothing was done. This was in 1931. She was treated, however, with a large radium pack at 10 cm. distance, 100,000 mg-hr. anteriorly and 100,000 mg-hr. posteriorly, divided into ten doses. This woman is still alive. She has a palpable tumor but is enjoying comparatively good health.

As to the use of morphine in cases of malignant disease, I think this is something the medical profession should take into consideration, particularly the practitioners who resort to morphine too early. Then at the time when it should be of the most benefit, it is of no value. Many minor surgical procedures and palliative treatments can make the remainder of a patient's life much more endurable.

Dr. Corscaden reports injuries to the bowel, probably due to too concentrated treatment with radium and roentgen rays. We have had 5 such cases, one requiring resection of the small intestine. It is interesting to note that the dosage in that case was not excessive, a small dose of roentgen rays and about 2,400 mg-hr. of radium intrauterine. The patient developed a partial obstruction of the small bowel about two years later. A second case was a uterine carcinoma and the patient developed obstruction of the sigmoid which required colostomy about eight years after treatment. The other 3

cases of injury to the mucosa of the rectum and sigmoid showed hemorrhage and ulceration and have been treated palliatively. Up to the present time no surgical intervention was deemed advisable.

Dr. Maurice Lenz, New York. Drs. Corscaden, Kasabach and I wished to emphasize in our paper that there seemed to be two reasons for the intestinal injuries following radiotherapy of cancer of the cervix in our cases. It is probable that in some cases, because of unrecognized anatomic deformities, the radium was nearer the particular portion of intestine which was injured than was realized; thus the intestine received a larger dosage than was intended. This has also been mentioned by Dr. Healy. In other patients, however, this was not the case and we believe that, in them, injury occurred because the treatment was given in too short a time.

The report of the Standardization Committee of the American Radium Society* presented at this morning's session points out that intestinal injuries complicating radiotherapy of cancer of the cervix were reported principally by those members of this Society whose entire radium treatment was given in less than 100 hours. We believe that insufficient emphasis has been placed upon the importance of prolonging the time for radium therapy in uterine cancer, especially when large doses of roentgen rays, e.g., by the Coutard method, are added. We fear that intestinal injuries such as reported by us will occur with increasing frequency unless the warning is heeded to extend the period of treatment when giving adequate radiation dosage in most cases of uterine cancer.

The importance of protracting the roentgen therapy in uterine cancer and thus avoiding injury to adjacent normal tissues is emphasized by Baclesse in Volume 3 of *Radiophysiologie et radiothérapie* of the Archives de l'Institut du Radium, on the basis of cases treated solely by roentgen therapy.

In his interesting paper Dr. Frazell discussed deficiency in dosage in and around the uterus which he tried to overcome by intracavity irradiation; I wonder whether this would not be better taken care of by the addition of external, especially higher, voltage irradiation.

Dr. Clarence F. Ball, Rutland, Vt. I had an opportunity to do a necropsy on a woman who was not satisfactorily treated. From that necropsy, I made several observations so far as results of treatment are concerned. The treatment that was given this case was prophylactic following a hysterectomy for early cancer of the cervix. The hysterectomy was performed in a small town in Vermont and the patient was sent to a larger city in another state where she received the so-called best treatment of twenty years ago. Those treatments were given as a fixed dose, irrespective of the body mass. At the time of the necropsy this woman weighed only 85 pounds. The particular finding made was the ablation of the mucosa of the gut in various sections. The finding that to me was most valuable was that the mucosa was destroyed most in the terminal loops of ileum as they lay over the prominence of the sacrum. I believe there is an additional amount of secondary radiation given off from the sacrum that should be considered. In this particular individual there was little damage to the mucosa of the ileum in the lateral areas of the abdominal cavity. I never saw this so well demonstrated as in Dr. Corscaden's cases this afternoon. His slides roentgenographically showed much the same conditions.

These discussions have referred to a definite dose without respect to the bulk of the individual to be treated. I think we should pay more attention to the relation of the proposed treatment to the mass volume of the individual in any series of treatments.

Dr. Charles L. Martin, Dallas, Texas. I would like to discuss these papers because of my interest in the effect of radiation on the intestine centered around some experimental work done at Baylor University Hospital about sixteen years ago. Although this work was published I have no doubt that even some of the older men may have forgotten it. When we first began to use radium in the treatment of carcinoma of the cervix with a technique which, I must admit was far from perfect, intestinal damage of the type described by Dr. Corscaden was soon encountered and we also believed that the ureters might be damaged as well.

Dogs were used as subjects and the effects of roentgen rays on the abdomen, as a whole, and on isolated intestinal loops were studied. We were able to produce every effect from a loss of function to intestinal obstruction in isolated loops with increasing doses. Irradiation of the whole abdomen produced various grades of

* Published in the August, 1937, number of the Journal, page 376.

toxemia, many of which were fatal, and we were convinced that true roentgen sickness in many instances resulted from the effect of roentgen rays on the intestinal mucosa.

Ureteral blockage could be easily produced with steel radium needles whereas the more modern weak radium needles used over longer periods of time gave a much larger margin of safety. This finding indicated that the prolongation of the treatment lessened the untoward effect on all normal structures.

After analyzing this work, no case of carcinoma of the cervix was treated in less than six days and since adopting this technique, we have noted no evidence of serious intestinal damage in our clinic.

Dr. Smith, in discussing complications, made no mention of parametritis and other pelvic infections which, when they occur during radium therapy, may be extremely serious. We have recently obtained what appeared to us to be a remarkable result with prontosil in the treatment of such an infection appearing after electrocoagulation of a cervical tumor and the intrauterine use of radium. I would like to know whether others have had a similar experience.

DR. GEORGE E. PFAHLER, Philadelphia. First of all, I appreciate, as all of you do, these excellent papers and especially the report which Dr. Lenz gave to us this morning.

I have had 4 of these bowel cases. Two of them were operated upon several years ago. At that time I thought there might be an extension from the carcinoma of the uterus but that was not the case. Two other patients who had a constriction of the bowel have symptomatically recovered and the lumen of the gut has increased, as was shown here.

The question is, what shall we do? First, I think it is not necessarily a question of excessive intrauterine dosage. I have had 2 cases in which this developed in connection with carcinoma of the bladder in which no radium was used. Second, it is not merely due to the treatment being crowded into a short time for in these bladder cases to which I refer the treatment in one case was carried over a period of four months and in the other over a period of nine months. It does, I believe, indicate an excess of irradiation which may not be avoidable if one aims at the destruction of the carcinoma.

I believe that we should, however, utilize the suggestions made by Dr. Lenz and Dr. Corscaden, that we should prolong our radium treatment and eliminate that factor. As was brought out, we probably get some of this effect because of the adherent gut, probably also associated with previous disease which led to the adhesions of the bowel to the uterus. The question is, how will we determine that there are adhesions? We probably can get some help, first, by giving a preliminary colonic injection so that we will know whether such constriction is present before we give the irradiation. Secondly, if we associate with that injection an injection of the uterus with lipiodol so that we can determine the relation of the bowel to the uterus, we can then probably reach conclusions in the future that will be of some value.

A third point is that we need not rush into resection, because some of these patients recover. We cannot definitely standardize our technique or the amount or character of the treatment until we can make carcinoma grow in a regular way. When we can say that a carcinoma will grow in a certain way then we can treat all of them by a standard technique but until then we must do the best we can with the information we now have.

DR. MILTON FRIEDMAN, New York. Undoubtedly the splendid results obtained in the treatment of carcinoma of the body of the uterus can be enhanced by improving the technique of inserting radium into the uterus. To date the available applicators have not been entirely satisfactory. They have been either too rigid, molding the uterus to fit the shape of the applicator, or else have consisted of a large number of individual tubes which frequently do not remain in the position in which they are placed and, in a large uterine cavity, drop to the bottom and become entangled. The applicator in my hand has been designed not only to provide flexibility and adaptibility to varying contours but also to provide regular, even distribution of radium. It can be bent so as to surround a fibroid and to reach to the cornu. There is a separate applicator which is inserted vertically, a string pulled, and the radium tubes occupy a horizontal position, so as to rest against the fundus. The filtration is very heavy, consisting of 1.5 mm. of platinum and 1 mm. of steel.

DR. SCHMITZ (closing). Dr. Lenz asked me to discuss the report of the Committee on Stand-

ardization and I do this with a great deal of pleasure.

The thought came to me, why seek in the distance when the good is so near at hand? The American grouping is now used in 75 to 80 per cent of all our clinics. If we adopt the international grouping, we will cause confusion. The international clinical grouping differs from the American grouping in that it includes movable parametrial involvement of one side in Group II, and fixation of the parametrium of one side in clinical Group III. The American clinical Group II includes invasion of the cervix and paracervical thickening, clinical Group III invasion of one or both parametria and clinical Group IV fixation of one or both parametria or invasion of vagina, bladder or rectum or systemic dissemination. The American clinical groups as evolved at Chicago appear more logical in their definitions.

The second point is the question of the single massive doses. If we learn to respect normal or even pathologic tissues I believe we will prevent injury of normal tissues. It has always been a question in my mind why we should use five or six fields to the pelvis when we remember that the anteroposterior diameter is 20 to 21 cm. in about 80 per cent of patients, and two or three fields of roentgen rays in combination with radium intrauterinely will give a fairly adequate and homogeneously distributed dose lateral and posterior to the uterus. The true bony pelvic cavity has a radius of 5 to 6 cm. Multiple fields invite deep-seated injuries by crossing of the multiple fields.

The treatment should be fractionated and spaced over four to six weeks. About 10 to 14 fractions each of 200 r with 200 kv. are given to each field at intervals of forty-eight to seventy-two hours. Using 800 kv. the homogeneity throughout the pelvis is ideal. The result is that radium may be dispensed with entirely or given in a small dose for its local effect. The three and four year good end-results with the latter method have been exactly 50 per cent.

Dr. Phaneuf (closing). I wish to thank Dr. Healy, Dr. Schreiner and the others for discussing my part of the program. Dr. Healy classified the treatment of corpus carcinoma admirably. In my paper I stated that my thought in bringing the subject for your discussion was that some light might be obtained and it has been. Dr. Healy's results, where radium, surgery and roentgen therapy were used, will lead to marked improvement in the future.

Dr. Schreiner showed that he has 43 per cent good results in his hospitals. If I had taken those cases treated with surgery and irradiation I could have improved my own results, but there were just 20 patients upon whom I thought an operation as extensive as ablation of the uterus would be fatal, and therefore, these old women, many of them with the disease in the advanced stage, were treated with radium and roentgen therapy alone, with a five-year survival of 25 per cent.

I wish to thank Dr. Friedman for showing his very ingenious types of applicators, which no doubt will greatly assist in treatment of carcinoma of the corpus and fundus. Probably all of us will use them at a later date.

Dr. Smith (closing). I cannot answer Dr. Lenz' question about the time factor in radium therapy, but some facts were brought out in a recent study of pyometra. I took the years 1926 and 1927 and the patients coming to us in those years as one group. As a second group I took the cases from the beginning of 1928 to 1931, and a third group included the cases seen from 1933 to 1936, inclusive. The reason for so dividing them was that in 1926–1927 we treated with radium first and then with the roentgen ray. In the next group we used roentgen therapy first, followed by radium therapy. In 1933 we began with an increasing percentage of divided dose technique. Two-thirds of the patients who showed pyometra before treatment were in the first group, 1926 to 1927. From that time on, we did not discover it except in a few isolated cases until after treatment had been given, but in the second and third groups there was a higher percentage of pyometra. In the 1933–1936 group we had a slightly higher percentage of pyometra but there was no difference in the group treated with the divided dose technique from those treated by massive dose technique. One would think this group would show some difference if time is a factor. It was of interest that the earlier lesions showed a higher percentage of pyometra than the more advanced cases.

One thing that I think is of some importance is that the highest incidence of pyometra, except in the untreated group, occurred in patients who received retreatment.

Dr. Corscaden (closing). I wish to discuss

just three points. First, duration of treatment. Up to a certain point we employed a certain technique. After that we employed the identical technique with the exception of prolongation of treatment. Prior to that change there was 8.7 per cent of intestinal injury. Since that time there has not been a single intestinal injury.

One point that I think those interested in roentgen therapy might be interested in was the element of cross firing. These ulcers were only 3 or 4 cm. long and were scattered all over the pelvis, one at the junction of the colon and the sigmoid, at the rectosigmoid and near the cecum. In only one case that we operated upon was there an adhesion between the intestine and the uterus. I feel that from the technical standpoint the roentgen rays are focused upon a certain point in the pelvis in each case and perhaps, in support of Dr. Frazell's paper, we should direct those rays away from the center line of the abdomen.

Vol. 39, No. 6

ULCERATION OF THE SMALL INTESTINE FOLLOWING IRRADIATION OF THE PELVIS

REPORT OF TWO CASES

By I. A. B. CATHIE

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WITH the increase in knowledge of the deleterious effects of roentgen radiation fewer morbid conditions are being produced during radiation treatment, but in spite of the improved results cases occur unexpectedly which not infrequently during treatment suffer damage proving of more consequence than the initial lesion for which treatment was administered.

Rolleston,[10] Desjardins,[4] and Colwell and Russ[3] have summarized the literature on radiation injuries and sickness, as well as the experimental work and various theories on the subject. Although there is a large mass of data available, the conflictions of the work prohibit the drawing of any definite conclusions, and at the present time the precise cause of roentgen sickness is obscure.

During the radiation treatment of nearly 400 patients for carcinoma of the cervix uteri, 2 developed intractable diarrhea and died, although the roentgen dosage was well within the limits of normal tolerance. Reference to the available literature showed only one case comparable to these two, and the rarity of the syndrome combined with the unknown etiology suggested the advisability of placing the latter cases on record.

The 2 cases of intestinal ulceration and death described here followed irradiation to the pelvis alone, and the technique of application was the same as that for some hundreds of other patients who stood the treatment with no adverse symptoms comparable to those of the two who died.

REPORT OF CASES

CASE I. Mrs. A., aged fifty-nine. History of three months' lower abdominal pain, and hemorrhage after coitus. Examination revealed a cervical carcinoma, proved by biopsy to be an epithelioma. General condition good. She received roentgen treatment over seventeen days. Treatment factors: 250 kv., 10 ma., filter of 1 mm. Cu + 1 mm. Al, intensity 50 r per minute; five fields, one anterior, 10×10 cm., two posterior and two lateral, each 10×15 cm.; dosage to the tumor 3,000 r. During the second week of treatment the stools began to be loose, and this progressed to a severe diarrhea, completely prostrating the patient, who died on the seventeenth day after the termination of treatment. Blood counts showed no gross abnormality.

At autopsy there was slight roentgen reaction over the hypogastrium and buttocks, a small mobile carcinoma was present in the cervix uteri, and most of the internal organs showed some degree of fatty change. Externally the gut appeared normal. Four and a half feet from the duodenum the jejunum was ulcerated, and the ulceration continued as far as the cecum, fading out sharply in the ascending colon. It was most severe in the jejunum, where most of the epithelium was destroyed on the summits of the valvulae conniventes, and continued through the ileum as small punched-out ulcers with hemorrhagic bases, and with no thickening of the gut wall. No blood was seen in the lumen of the intestine.

Culture of the feces during life and post mortem revealed no pathogenic bacteria.

CASE II. Mrs. B., aged forty-two. History of four months' loss of weight, discharge and hemorrhage from the vagina. On examination there was an ulcerating growth on the cervix, proved histologically to be an epithelioma. The general condition was good, and roentgen treatment of the carcinoma was given. The details of treatment were as for the first case, except that the intensity was 120 r per minute. During the second week of treatment diarrhea commenced and became very severe, the patient's condition deteriorating rapidly. Thirty days after finishing the course of roentgen treatments the diarrhea lessened somewhat, but eleven days later there was an acute exacerbation under

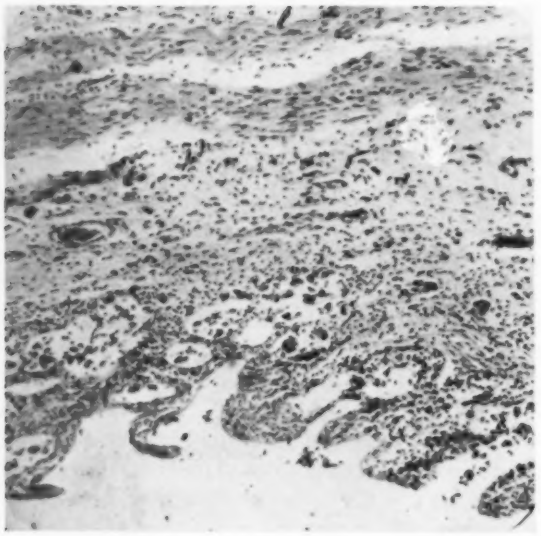

FIG. 1. Photomicrograph of jejunum in a non-ulcerated area, showing general necrotic state of the epithelium. Hematoxylin and eosin. ×65.

which the patient collapsed. She died fifty-one days after finishing treatment. Blood counts showed a slight anemia only.

At autopsy there was roentgen reaction over the hypogastrium and buttocks, a carcinoma of the cervix infiltrating widely the parametria, and an oldstanding myocarditis. The appearance of the gut *in situ* presented no abnormality. From the last part of the duodenum to the rectum was a condition of severe ulceration, more acute in the small intestine. In the colon the average size of the ulcers was about 4×4 cm., the edges were heaped up and the bases indurated and covered by a greyish slough. In the small intestine, on the other hand, the average size was about 1×1 cm., ulcers were more frequent, and had sharp, punched-out edges, very little induration and a pink, hemorrhagic floor.

Culture of the feces was negative for pathogenic bacteria.

Histology. The microscopical appearances of the ulcers in the small intestine were the same in both cases. In no part was the mucous membrane healthy. Where present it appeared atrophic or degenerated, the cells being vacuolated, with small, pyknotic nuclei and a chromophobe cytoplasm, while all semblance of a columnar shape was lost (Fig. 1). The composite picture was suggestive of an ischemic necrosis of epithelium, but no abnormality was seen in the submucous layer of the intestine, apart from some infiltration of lymphocytes and plasma cells. The blood vessels appeared patent and healthy (Fig. 2).

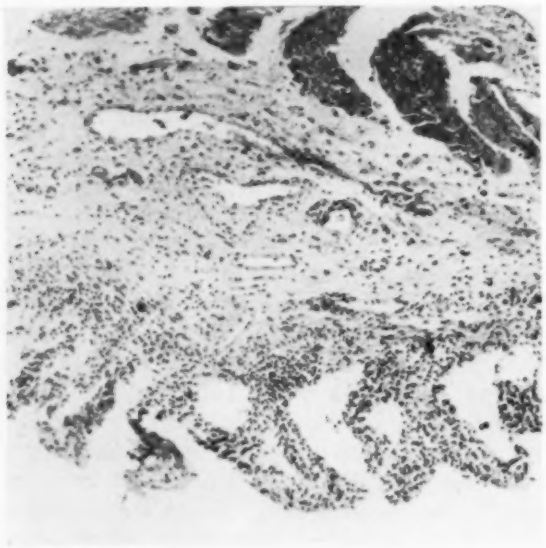

FIG. 2. Photomicrograph showing necrotic epithelium with healthy underlying blood vessels. Hematoxylin and eosin. ×65.

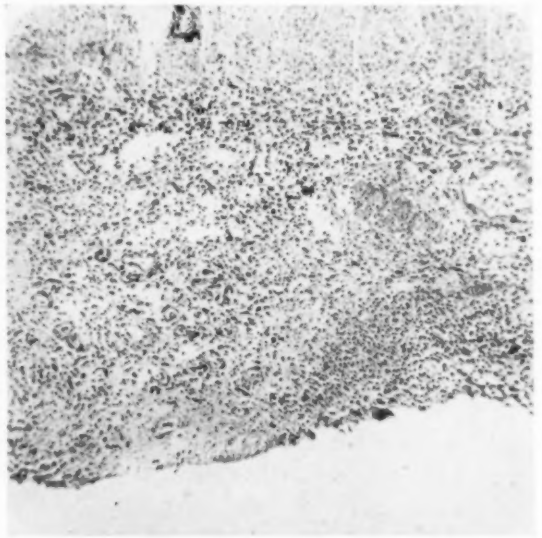

FIG. 3. Photomicrograph from the base of a jejunal ulcer, with chronic inflammatory changes. Hematoxylin and eosin. ×60.

In the areas of ulceration no more striking features were noticed, the epithelium was simply cast off, and acute inflammatory reaction was conspicuous by its absence. Here and there early hyalinization of the connective tis-

sue was seen, and a few small clumps of bacteria were adherent to the exposed surface (Fig. 3). An occasional giant cell and a few lymphocytes and plasma cells were present in the submucosa, but in far fewer numbers than were expected from the macroscopical appearance.

DISCUSSION

These two cases occurred in a series of between three and four hundred, both in the same month, and appeared suddenly in the otherwise uneventful radiation treatment of uterine carcinoma. Although transient diarrhea was a fairly common sequel to roentgen treatment, in no other case was it at all alarming or dangerous to life.

Roentgen ulceration of the large intestine is comparatively frequent, especially following high dosage, but the contrasting features of these two cases are, first, that ulceration was found in the small intestine predominantly, and as high up as the duodenum, structures well removed from the fields of irradiation, and second, that diarrhea occurred during the second week of treatment, when only about 1,500 r had been delivered to the uterus. This figure is far below the usual tolerance dose of small intestine mucosa, low though this tolerance is.

A good many authors mention ulceration of the small intestine following roentgen therapy for other than pelvic diseases (Fisher,[7] Haendly,[9] Desjardins[4]), but the only report comparable with the present cases found in the literature is that of Franz,[8] whose patient died with ulceration throughout the small intestine and colon, six weeks after termination of treatment for carcinoma of the cervix. Ball[1] mentions a case in which two loops of ileum overlying the sacral promontory were gangrenous, but such a localization of the pathological change suggests a localization of cause, such, possibly, as secondary radiation from the vertebrae. The generalized ulceration throughout the small intestine in the present cases almost eliminates the possibility of a direct action of roentgen rays, and infers more a systemic effect manifested locally in the gut.

Obscure points are the factors predisposing to the ulceration, and the actual cause of death. Against such theories as the unskillful application of radiation and secondary radiation is the fact that diarrhea, presumably one of the first responses to intestinal damage, occurred when such a small r dosage had been delivered. The possibility of some form of dietary irregularity has to be considered, but as the diet received was standardized and shared by the other patients successfully treated there is no justification for supposing that this factor was significant. Evidence against an infective origin for both cases was the failure to grow pathogenic bacteria on any occasion. Further, the temperature charts of both patients were within normal limits during the illness. In the same way that cases of burns sometimes develop duodenal or jejunal ulcers, it is possible that the skin radiation reaction zones may have liberated some histamine-like substance which caused the ulceration, but in view of the lack of any evidence either way this must perforce remain pure theory.

The ultimate reason why these two patients should have died, while the transient diarrhea experienced by many others cleared up spontaneously, indicates that either the diarrhea was sufficiently severe to cause death from dehydration and its sequelae, or else that some entirely different factor was at work. The emaciated and cachectic state in which both patients died points to dehydration playing some part in the terminal event, in spite of the fact that plenty of fluids were being taken by mouth and parenterally. Franz mentioned the striking amounts of bacteria accumulated upon the necrotic intestinal areas in his case, and thought that in the terminal stages bacteria entered the blood stream. Small clumps of bacteria were noted in the present cases, and in one case the temperature rose to 102° F. two hours before death, an observation that would tend to support Franz's conclusions.

Edsall and Pemberton[6] thought that products liberated by the irradiation of lymph-

oid tissues might cause sickness; Burgheim[2] thought malaise to be due to a concomitant hypocholesterolemia, and Dodds and Webster[5] concluded that irradiation of the abdomen produced metabolic changes. These observations, and many others quoted by Desjardins,[4] Rolleston,[10] and Warren and Whipple[11] are applicable to the present cases, which probably are severe and fatal examples of irradiation sickness. The many observations and theories lack any common factor, and pending the production of evidence pointing to a specific etiology one is forced to the conclusion that certain individuals present the idiosyncrasy that their tolerance to roentgen radiation is markedly below the normal, and that what is a normal dose of radiation for the ninety-nine persons may in the hundredth produce an effect, the mechanism of which is as yet unknown, but which may prove fatal.

In conclusion, it must be emphasized that anything but the most transient diarrhea should be regarded with the gravest concern, lest the treatment prove more harmful than the disease.

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Vol. 39, No. 6

A ROENTGENOLOGICAL STUDY OF PINEAL ORIENTATION

III. A COMPARISON OF METHODS USED IN PINEAL ORIENTATION*

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THE method of Vastine and Kinney[6] for pineal orientation has now been in use for ten years and has proved to be a workable method of considerable value when properly employed. This method was derived from a graphic analysis of a series of normal cases, plotting the distance of the pineal from the frontal bone against the long or anteroposterior diameter of the skull and the distance of the pineal from the vertex against the vertical diameter of the skull. By thus determining the range for normal pineals, any position outside the normal zone was assumed to be the result of displacement. Dyke[1] has shown that the main error in this method is due to the frequent finding in normal cases of a considerable number of pineals lying anterior to the normal zone. For this reason he has recently advised[2] moving the normal zone forward 4 mm. Lilja[5] has made a statistical study of pineal orientation employing measurements of the distances between the pineal and numerous selected points on the calvarium including these used in the graphic method.

For the past five years we have used a proportional method[4] which eliminates the need of consulting charts or making direct measurements with a rule. The method incorporates the use of an elastic cord upon which are placed markers defining the normal zones for both the long and vertical diameters of the skull. This cord stretches uniformly throughout its length so that when the zero or beginning marker is placed at the inner table of the frontal bone and the cord is stretched with the end marker at the inner table of the occipital bone, normal pineals will fall within the normal zone indicated on the stretched cord independent of the actual or absolute measurements of the skull (Fig. 1). The method in its essential principle expresses the distance of the pineal from the calvarium as a fraction of the total length or height of the skull. The

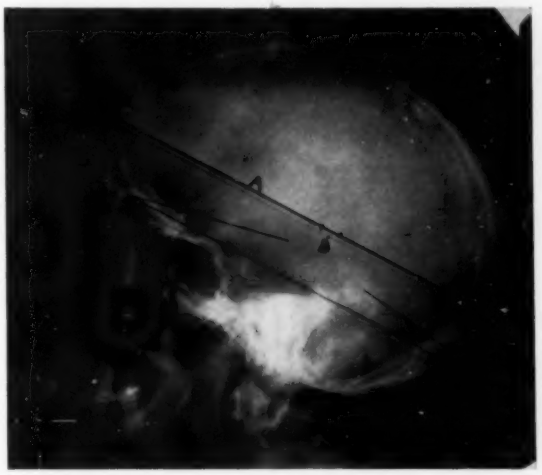

FIG. 1. Pineal measurement by the proportional method. A transparent guide has been placed over the skull with the stretched elastic cord, *A* (black line along upper border of the guide) extending along the anteroposterior diameter of the skull. The pineal indicated by the dot, *B*, lies between the two markers located on the stretched cord indicating a normal position for the pineal. The two markers for making measurements along the vertical diameter of the skull have been purposely removed to avoid confusion. The black lines (angles) along the lower margin should be ignored. Their use will be shown by subsequent illustrations.

distance of the pineal from the frontal bone varies from 55–60 per cent of the total anteroposterior diameter of the skull and the distance of the pineal from the vertex varies from 51–57 per cent of the vertical diameter of the skull.

This method has been found to material-

* From the Department of Medicine, Division of Radiology of the University of Rochester School of Medicine and Dentistry and Strong Memorial Hospital, Rochester, New York. Presented at the Fifth International Congress of Radiology, Chicago, Ill., Sept. 13–17, 1937.

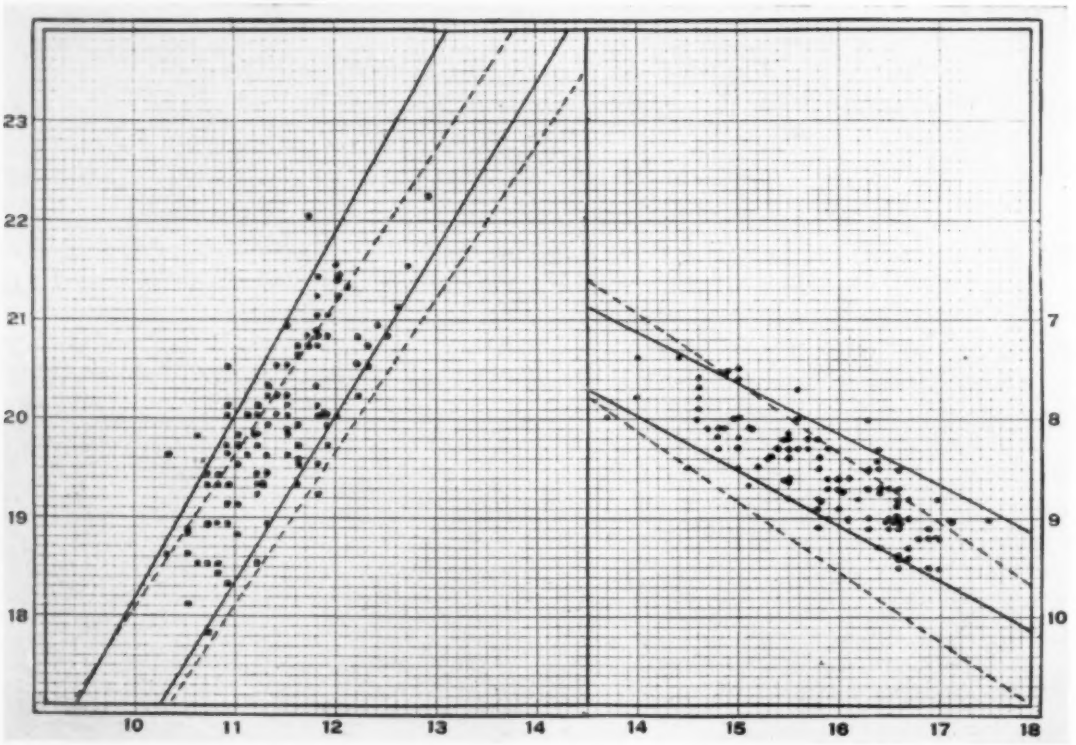

Fig. 2. Distribution of pineals in a series of 104 normal cases comparing the graphic method (broken lines) and the proportional (solid lines). The graph to the left of this and all following illustrations refer to measurements along the anteroposterior diameter of the skull, the distance of the pineal from the frontal region being the abscissa and the anteroposterior diameter of the skull being the ordinate. The graph to the right employs the vertical diameter as the abscissa and the distance of the pineal from the vertex as ordinate. Pineals falling to the left or right of the zones of the first graph are interpreted as falling anterior or posterior to the normal zone respectively, while pineals falling above or below the second graph indicate positions of the pineal above or below the normal zones. Note that as the skull length increases (ordinate of left graph), the position of the normal zone of the proportional method shifts anteriorly, thereby eliminating many of the false normals resulting from the use of the graphic method.

ly reduce the number of false normals usually noted in the graphic method of Vastine and Kinney. In an analysis of 104 normal cases, the number of false normals lying outside of the normal zone has been reduced to approximately one-half (17 cases to 8 cases, Fig. 2, Table 1). Dyke's modification of the graphic method succeeded in reducing the number of normal pineals lying anterior to the normal zone to one-fourth. However, the method suffered the disadvantage of greatly increasing the number of pineals (13) lying posterior to the normal zone. The percentage appearing displaced was not altered as a result (Fig. 3, Table 1). The expedient was tried in this series of moving the normal band forward 2 mm. rather than 4 mm. as suggested by Dyke. A slight improvement resulted, the false normals being reduced from 17 to 13 (Table 1).

An additional method (cranioangle) has been devised by us avoiding the use of linear measurements of the skull. A transparent guide with two ruled lines forming an angle with each other of 8° is placed with the vertex of the angle at the opisthion (posterior margin of the foramen magnum) the main line going through the bregma (Fig. 4). Normal pineals are then distributed in the angle formed by the main base line and its fellow, displacement being detected by any position of the pineal lying outside the lines forming the angle. For identifying

TABLE I

POSITION OF PINEAL IN 104 NORMAL CASES

Anteroposterior Plane of Skull

	Normal Zone	Anterior to Normal Zone	Posterior to Normal Zone	Total	Percentage Appearing Displaced
Graphic method	87	16	1	104	16+
Modification No. 1 (4 mm.) Dyke	87	4	13	104	16+
Modification No. II (2 mm.)	91	8	5	104	13+
Proportional method	96	5	3	104	8−
Cranioangle method	90	3	7	100	10

Vertical Plane of Skull

	Normal Zone	Above Normal	Below Normal	Total	Percentage Displaced
Graphic method	93	11	0	104	11−
Proportional method	97	3	4	104	7−
Cranioangle method	98	1	1	100	2

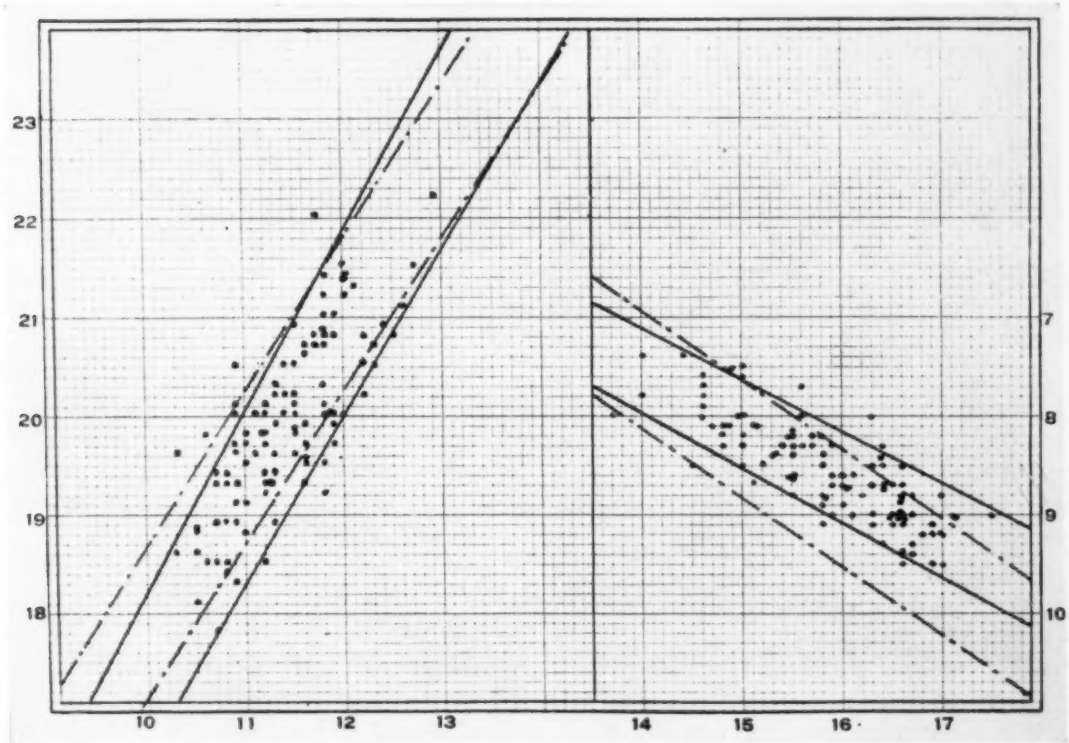

FIG. 3. Distribution of pineals in a series of 104 normal cases comparing the Dyke modification of the graphic method (broken lines) with the proportional method (solid lines). Note that as the skull length decreases (ordinates of the left graph) the normal zone of the proportional method shifts posteriorly in respect to the normal zone of the Dyke modification. The chief error in the latter method relates to the relatively large number of normal pineals situated behind the normal zone.

Fig. 4. Pineal measurement by the cranioangle method (determining displacement along the vertical diameter of the skull). The vertex of the angle (8°) is placed at the opisthion (posterior margin of the foramen magnum), the main base line extending through the bregma. Pineals which are in normal position fall within the two lines forming the angle.

displacement downward or upward the vertex of the angle is placed at the base of the anterior clinoids, the main line passing through the lambda (Fig. 5). Pineals lying between two lines forming an angle (11°) are considered normal, others are displaced upward or downward according to the position of the pineal above or below these lines. In the series of 104 normal cases, 3 were located anterior and 7 posterior to the normal zone, while 1 was located above and 1 below the normal zone (Fig. 6). Four cases showed the position of the lambda or bregma so indistinctly that the measurement could not be safely made.

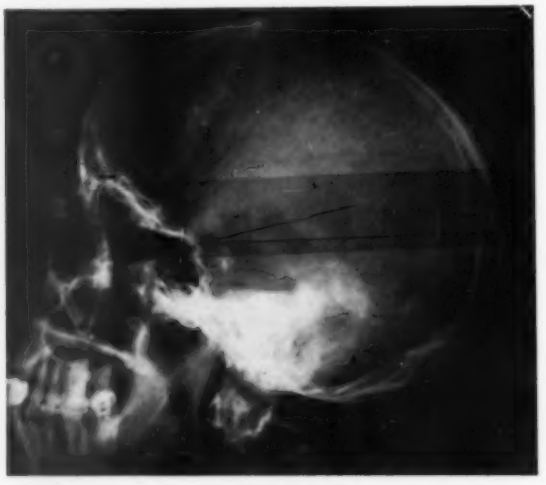

Fig. 5. Pineal measurement by the cranioangle method (determining displacement along the anteroposterior diameter of the skull). The vertex of the angle (11°) is placed at the base of the anterior clinoids (top of tuberculum sellae). The long arm of the angle extends through the lambda. Pineals located in normal position fall within the two lines forming the angle.

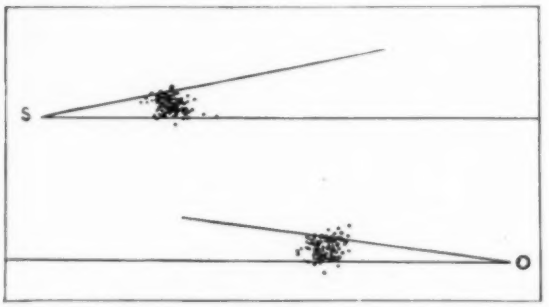

Fig. 6. Distribution of pineals in 100 normal cases by the cranioangle method. The upper angle, the vertex of which is placed at the base of the anterior clinoids includes all cases showing typical normal position. The ones located above or below the lines forming the angle represent false normals (superior or inferior displacement). The lower angle, the vertex of which is placed at the opisthion includes all cases showing typical normal position. The ones located above or below the lines of the angle represent the false normals of this series and would be interpreted as posterior or anterior displacements respectively.

The cranioangle method showed fewer false normals than the method of Vastine and Kinney or the modification of this method suggested by Dyke. When compared with the proportional method, it did not decrease the number of false normals in respect to the anteroposterior axis of the skull but did materially reduce the number along the vertical diameter. It suffers the disadvantage of making the identification of the selected points of the calvarium, the bregma and lambda obligatory if the method is to be carried out. It possesses the great advantage of correctly locating the normal position of the pineal in skulls of heterogeneous shapes and types (Figs. 7 and 8).

The graphic, proportional and cranioangle methods have been compared in 148 cases of brain tumor, proved either by operation or autopsy (Table II). These have been divided according to the location in respect to the brain. Of the 37 frontal tumors 17, or nearly one-half, showed no displacement of the pineal by the graphic method. As a result of moving the normal band forward 4 mm. (Dyke's modification) this number was reduced to 7. The proportional method showed 9 cases with pineals in normal position and the cranioangle

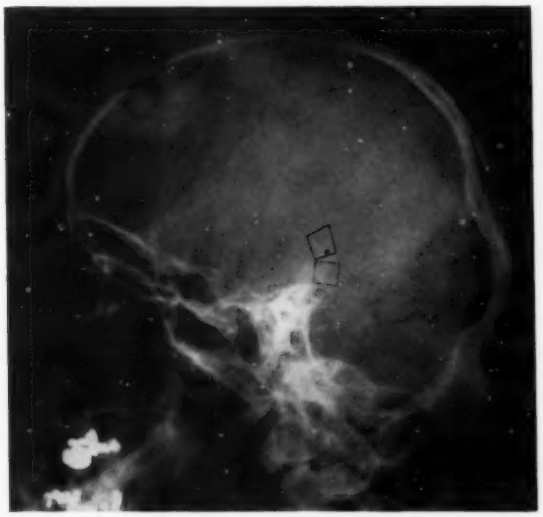

Fig. 7. Normal case without brain tumor. Skull with long vertical diameter due to unusually low posterior fossa. The graphic method (broken lines) places the pineal in a very low position while the cranioangle and proportional methods (latter not illustrated) places the pineal within normal range.

method 6 cases. The direction of displacement was most frequently backward, though a combination of backward and downward displacement was not uncommon (Fig. 9). Comparing the methods, the proportional and cranioangle methods appear most reliable since the Dyke modification yields approximately 13 per cent error in regard to posterior displacement in the normal series. Upward displacement was not encountered in this series. Forward displacement was observed only when the graphic method was employed (2 cases).

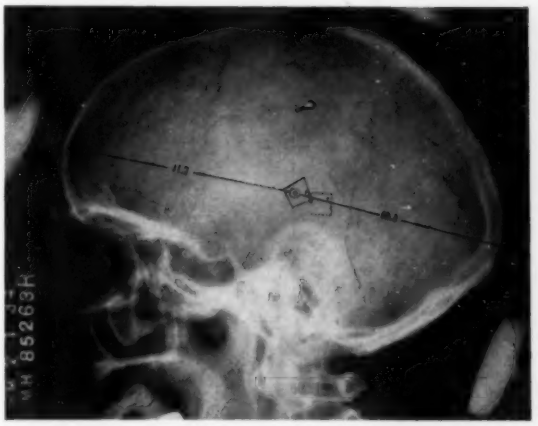

Fig. 8. Normal skull of dolichocephalic type with long anteroposterior diameter of 22 cm. The range of normal position indicated by solid lines for the cranioangle method and by broken lines for the graphic method. The two dots represent the normal range for the proportional method. In this case only the cranioangle method correctly places the pineal; the other methods indicate posterior displacement.

This obviously represents an error in the method.

Temporal tumors, which were next most

Fig. 9. Frontal tumor without localizing signs except for pineal. The dot represents center of pineal. The position of the pineal falls within normal limits by the graphic method of Vastine and Kinney (short broken lines). The proportional (long broken lines) and cranioangle (solid lines) methods both indicate posterior displacement.

TABLE II

POSITION OF PINEAL IN PROVED CASES OF BRAIN TUMOR

	N*	F	B	U	D	B.D.	U.B.	U.F.	Total	Percentage Displacement
Frontal										
Graphic	17	2	10	0	4	4			37	54
Dyke modification	7	0	22	0	1	7			37	81
Proportional	9	0	17	0	0	11			37	76
Cranioangle	6	0	9	0	5	15			35	83
Temporal										
Graphic	19	0	3	2	3	0	0	2	29	34
Dyke modification	15	0	7	2	0	3	1	1	29	48
Proportional	18	0	3	0	4	3	0	1	29	38
Cranioangle	13	0	8	0	3	2	0	0	26	50
Parietal										
Graphic	5		3		0	0			8	37
Dyke modification	3		5		0	0			8	63
Proportional	3		1		2	2			8	63
Cranioangle	1		0		4	3			8	87
Cerebellar and petrous apex tumors										
Graphic	15		1	1		0	1	3	21	29
Dyke modification	15		2	3		0	0	1	21	29
Proportional	16		1	4		0	0	0	21	24
Cranioangle	12		3	1		1	1	0	18	33
Pituitary and suprasellar tumors										
Graphic	7	3	0	2	0	0		2	14	50
Dyke modification	8	0	2	4	0	0		0	14	43
Proportional	9	1	0	3	1	0		0	14	36
Cranioangle	10	0	3	0	0	0		0	13	23
Middle fossa tumors. Third ventricle tumors. Aneurysms at circle of Willis										
Graphic	5	4	0	0	0	1			10	50
Dyke modification	8	0	1	0	0	1			10	20
Proportional	8	0	1	0	0	1			10	20
Cranioangle	8	0	1	0	0	1			10	20
Pineal										
Graphic	4					2			6	33
Dyke modification	3		1			2			6	50
Proportional	4					2			6	33
Cranioangle	1		2	2		1			6	83
Surface fluid at convexities										
Graphic	4		1	1	1	0			7	43
Dyke modification	4		1	1	0	1			7	43
Proportional	5		1	0	1	0			7	29
Cranioangle	3		1	0	0	1			5	40

* Symbols—N = normal, F = forward displacement, B = backward displacement, U = upward displacement, D = downward displacement.

frequently observed, did not show pineal displacement on the lateral film as frequently as frontal tumors, being found in normal positions in one-half or more of the cases by all methods (Fig. 10). The cranioangle method showed the greatest number of cases with pineals lying outside the normal zone. The direction of displacement was commonly posterior. The combination of downward and backward displacement was much less frequently seen than in the frontal tumors.

Tumors located with their main bulk in the parietal region are less frequent in this series, the direction of displacement varying with the method. The graphic method including the Dyke modification usually indicated a posterior type of displacement, while the proportional and cranioangle methods more often indicated a downward displacement or combination of backward and downward displacement. It becomes evident that it is impossible to localize a mass within the individual lobes of the brain by any of the methods of analyzing the lateral film, since tumors within the frontal, temporal and parietal lobes all produce much the same type of displacement—either backward or downward and backward. Occipital tumors are infrequently observed, only one being noted with its greater bulk in the occipital lobe.

Tumors at the base of the brain or along the floor of the skull do not produce displacements frequently and the type of displacement varies widely in the same group with the method used. Sellar and suprasellar tumors show no consistent type of displacement, the direction varying considerably according to the method employed. Occasionally, however, the pineal appears in a position above the normal zone when measured by the graphic or proportional methods. Aneurysms at the circle of Willis and middle fossa tumors located near the midline show displacement uncommonly, though rarely their bulk may be sufficient to displace it posteriorly or downward and backward. Pineal tumors, by blocking the outlet of the third ventricle, may distend the ventricle sufficiently to crowd the pineal posteriorly.

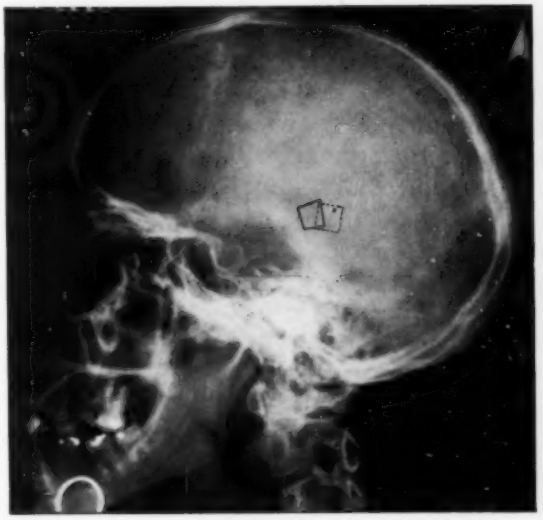

Fig. 10. Temporal tumor. The pineal is shown falling within the normal zone by the graphic method (broken lines), while the cranioangle method indicates posterior displacement.

Tumors lying below the tentorium are most frequently observed in youthful subjects (cerebellar tumors). Due to the relative infrequency of calcification in the pineal in youth, the data concerning pineal displacement are meager for this group of tumors. In practical diagnostic work, the orientation of the pineal does not aid materially in localization. Petrous apex tumors, on the other hand, occur in the more advanced age periods and in these tumors the pineal though calcified is usually not significantly displaced. When displacement is present, it is usually upward, varying according to the method, the graphic showing a greater number with forward and upward displacement of the pineal.

Metastatic tumors may displace the pineal as well as primary tumors. The frequency and type of displacement undoubtedly vary with the location of the mass. Since these tumors do not calcify with the frequency of primary tumors and signs of increased intracranial pressure are often absent, a displaced pineal may be the only evidence of a metastatic mass within the brain or cranium.

Similarly, fluid collections of blood at the brain surface, clotted hemorrhage or pachymeningitis may displace the pineal, though measurements of the anteroposterior film are usually more significant than those of the lateral film.

The determination of a lateral shift from measurements[3] of the anteroposterior or posteroanterior film should be carried out in all cases of suspected brain tumor, since this may be the only abnormality noted. In our series, it occurred in over one-half of the cases with frontal lobe tumors and in all cases of temporal and parietal tumors in which the pineal could be identified on the anteroposterior film (Table III). It was not displaced in cerebellar or sellar tumors, but was frequently noted displaced in cases in which hemorrhage, old or recent, was present. Frontal lobe tumors produce displacement which can be detected more frequently by examination of the lateral skull film (one-half to three-fourths of cases according to the method employed), while temporal and parietal lobe tumors produce displacement which is more frequently detected in the anteroposterior film (practically 100 per cent of those cases in which the pineal can be identified on this film while the lateral film shows displacement in less than one-half of the cases). This finding is of real importance since it emphasizes the need to identify the pineal in all projections. Because the pineal is seen with much more difficulty on the anteroposterior film, it is necessary to increase the care used in technique. The focal spot size is most important, a tube with a rotating target affording an opportunity to visualize the pineal in cases in which other tubes failed. In any suspected case of brain tumor the films should be repeated if the pineal appears in normal position on the lateral film and cannot be seen on the anteroposterior film.

TABLE III

POSITION OF PINEAL IN PROVED CASES OF BRAIN TUMOR

Lateral Displacement

	No. Displaced	Total Number	Percentage Displaced
Frontal	13	23	56
Temporal	14	14	100
Parietal	4	4	100
Posterior fossa	1	9	11
Sellar and suprasellar	0	7	0
Third ventricle. Aneurysm of circle of Willis	2	8	25
Surface fluid at convexities of brain	3	5	60

CONCLUSIONS

1. The proportional method compared with the original Vastine and Kinney method has reduced the error in normal cases approximately 50 per cent for measurements along the anteroposterior diameter and 33 per cent for measurements along the vertical diameter.

2. A cranioangle method has also been devised which is useful in skulls with diverse shapes. In normal cases, its accuracy is nearly as great as the proportional method for measurements made along the anteroposterior diameter and surpasses all methods for measurements made along the vertical diameter.

3. The Dyke modification did not improve the accuracy in normal cases. While it decreased the number of false normals indicating anterior displacement, it greatly increased the number of false normals indicating posterior displacement with the result that there was no improvement in general results.

4. In proved cases of brain tumor, pineal displacement was more frequently detected by the proportional and cranioangle methods than by the original graphic method

of Vastine and Kinney. Due to the fact that the most common type of displacement relating to the lateral film by brain tumors is backward, the moving forward of the normal band of the graphic method, as proposed by Dyke, has resulted in yielding a high incidence of posterior displacement which might be interpreted as increasing the accuracy of the Vastine method in tumor cases. However, the high incidence of posterior position of the pineal in normal cases makes it difficult to distinguish an error in a normal case from true posterior displacement in a tumor case.

5. Tumors of the frontal lobes most frequently show posterior displacement on the lateral film, while this is less commonly seen in temporal and parietal tumors.

6. The detection of a lateral shift may be the only displacement noted in many cerebral lobe tumors, particularly, however, those of the temporal or parietal lobes in which the lateral shift is present in practically all cases.

7. The analysis of the type of displacement does not yield positive information regarding sharp localization in the cerebral lobes, though an analysis of the data may permit the elimination of tumors in certain regions, thereby narrowing the possibilities or may render tumors in some regions unlikely. If, for example, a lateral shift is absent, a temporal tumor may be safely eliminated.

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THE INCIDENCE OF ENLARGED THYMUS FOLLOWING THE PRENATAL USE OF IODIZED SALT*

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THE THYMUS gland, because its true function is not known, has in the last decade been subjected to repeated investigation. This is due in part to the increasing interest in endocrinology and in part to the fact that improved methods of roentgenographic examination have aided in demonstrating the presence of an upper mediastinal widening which in many instances has been interpreted as an enlarged thymus.

Galen was the first observer to note that the thymus underwent involution, and he also recorded that it reached its maximum size at puberty.[13] Tables compiled by various investigators have been published[10] showing the weight and measurements of the thymus gland at various periods of life and its relation to body weight. Bovaird and Nicoll[2] imply that the thymus varies in size with different stages of nutrition and ill health, and have published a table of the weights at autopsy of the thymuses of 495 patients. This finding is not the rule in all wasting conditions, as Warthin,[46] Potter,[42] and Margolis[28] have found thymus hyperplasia in thyroid disease. The association of enlarged thymus in children overweight at birth may, as some observers have pointed out, be due to the fact that the size of the thymus is proportionate to the body weight.[44] Again, such a condition may be due to hypothyroidism or to adrenal or gonadal disturbance.

Marine, Manley, and Baumann[30] have noted that thyroidectomy hastens the involution of the thymus. Warthin,[46] Marine[29] and other writers have shown a relationship between thymus and lymphoid hyperplasia as associated with the so-called lymphatic constitution. Warthin[46] states that "the most constant and striking feature in the pathology of exophthalmic goiter is the hyperplasia of the primitive lymph nodes of the thyroid, with the production of large germ centers showing characteristic lymphoid exhaustion of the lymphatic constitution." He also observes that "the effects of the administration of iodin to patients with Graves' disease are very marked histologically, as colloid begins to reappear and lymphoid tissue decrease in amount." The conditions known as toxic goiter and toxic adenoma, he maintains, are pathologic reactions potentially predetermined by virtue of a constitutional anomaly. Marine[29] thinks that these conditions may also be acquired. The congenital aspect is not a particularly new theory, for as early as 1889 Paltauf[37] expressed the opinion that thymus enlargement was a manifestation of a constitutional disorder—status lymphaticus—and Klose[13] believes that thyrotoxic goiter does not exist without thymus enlargement. Boyd[3] has recently questioned that the condition of status lymphaticus is abnormal.

Young and Turnbull,[48] in an analysis of the data collected by the status lymphaticus investigation committee, state that there is no association between the weight of the thymus and the amount of lymphoid tissue found in various parts of the body, and that in normal subjects under sixteen years of age the number of deaths inadequately explained is no greater among those with a thymus of normal weight. Their finding coincides with that of other writers in that hyperthyroidism subjects show weight of the thymus above normal. The conclusion of the committee is that

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status lymphaticus has no existence as a pathological entity.

The thymus has not been definitely considered as a gland of internal secretion, but the frequent association of hyperplasia of the thymus with thyroid disorders indicates an interrelationship of these two glands.[13] Numerous writers have reported on large series of patients with thyroid disease and have been in accord in these findings: that more than half of the patients had thymus hyperplasia; that the thymus hyperplasia was found more frequently in young thyrotoxic individuals than in older ones; and that histologically there was no difference between the hyperplasia of the thymus associated with thyroid disease and the hyperplasia not accompanied by thyroid disorder. Kocher[13] believes that in most cases the thymus hyperplasia existed prior to the thyroid disturbance, and for that reason he does not believe it to be a direct cause of the disturbance. Potter[42] has reported a series of autopsies of patients with Graves' disease in 45 per cent of whom he found thymus hyperplasia. Margolis[28] reviews the literature and adds to it a conclusive study of the relationship of the thymus gland in hyperthyroidism, pointing out that the thymus gland frequently presents parenchymatous hyperplasia in hyperthyroidism and that, in general, the degree of hyperplasia is much more pronounced in cases of exophthalmic goiter than in cases of adenomatous goiter with hyperthyroidism. Boyd[3] in 1932 stated, "when illness has lasted longer than 24 hours, the weight of the thymus is reduced regardless of the cause of death with the exception of tumors of the thymus, leukemia and exophthalmic goiter."

It seems apparent from this review of the literature that there is a definite association between the thymus gland and certain thyroid disease.

It is apparently an established fact that in Michigan a high incidence of thymic hyperplasia has been fairly common in infants. Miller and Peterson,[32] Hardy,[19] Greenthal,[17] Donaldson,[11] and Cooperstock[9] have all reported series of studies of cases in the past fifteen-year period in each of which the incidence has been comparatively high for both newborn and older children. Clinical reports from the East and from the southern portions of our country lead us to believe that cases of thymic enlargement are not of such common occurrence. Similarly, the roentgenologic literature from the southern states and from the Southwest contains very little pertaining to the problem of enlarged thymus. The statement of Holt and Howland[22] that enlargement of the gland seems to be more frequent in certain localities lends further support to our conclusion.

Referring to the map of thyroid incidence (Fig. 1) prepared by McClendon and Williams,[13] we see that the state of Michigan and the region of the Great Lakes are in one of the most heavily shaded areas, in contrast with the southern and eastern sections of the country. It is not questioned, however, that in the last ten years there has been a marked reduction in the incidence of simple thyroid enlargement in school children of Michigan.

A survey made in 1923 under the direction of the State Department of Health showed beyond a doubt that there is a correlation between the scarcity of food iodine and the high incidence of simple goiter. It also revealed that in certain localities with an iodine water content of zero, 64.4 per cent of those examined had thyroid enlargement. In a locality where the iodine content of the water was 8.7 parts per billion the thyroid abnormality was 26 per cent. Following the survey an intensive campaign was inaugurated to bring about the use of iodized salt. This measure was not made compulsory by law, but was, rather, urged by means of education and advice as to methods of prevention of endemic goiter.

The statistics compiled from this survey were based on examinations of over 65,000 school children who showed a thyroid incidence of 38.6 per cent. In 1928, after iodized salt had been in use, 50,000 school

children examined in these localities showed a goiter incidence of 9.9 per cent. A survey completed in 1935 disclosed that the incidence had dropped to 8.2 per cent. The figures of the latter study show that there has been a reduction varying from 74 per cent to 86 per cent in the incidence of thyroid enlargement in school children in those localities where iodized salt has been used consistently.[24] Meanwhile, McClure[26] has pointed out that toxic diffuse and toxic nodular goiter operations were reduced as much as 50 per cent up to 1934, and that while from 1926 to 1932 there was a gradual increase in the total number of operations in seven leading hospitals of Michigan, there was a noticeable decrease in goiter surgery.

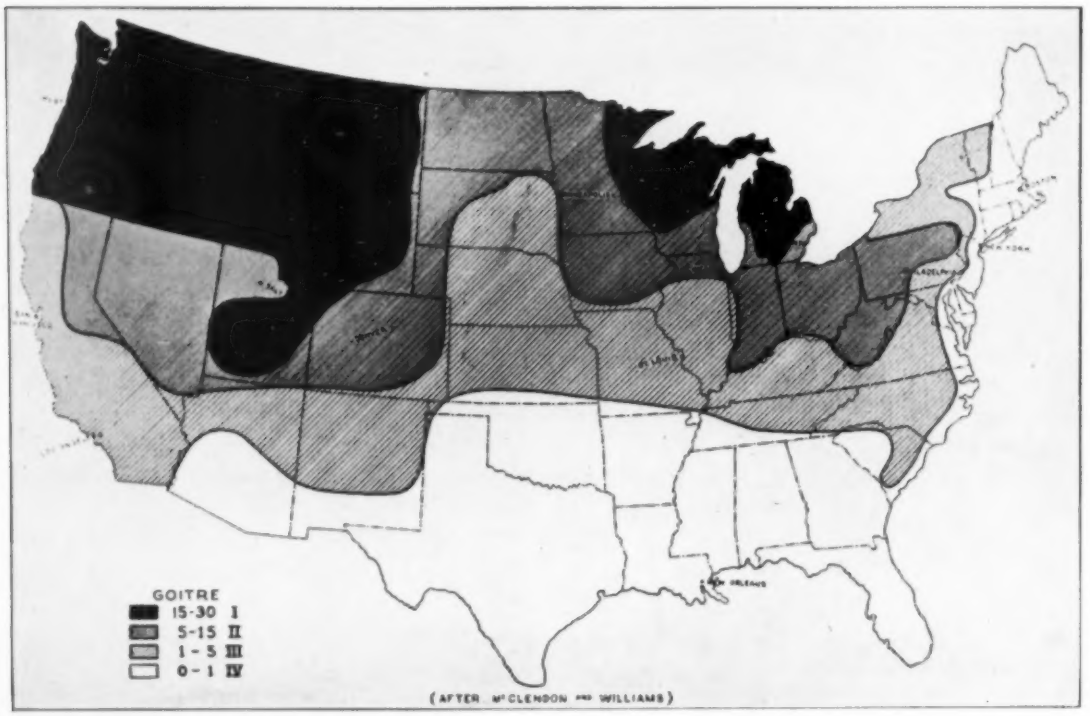

FIG. 1. Regional distribution of goiter in the United States. (After McClendon and Williams.)

It is upon this basis of the above observations that we became interested in the question of the status of the thymus gland in the newborn of mothers who had been residents of a state where iodized salt had been in use for a period of years.

The study of this series of cases was begun with the assumption that enlarged thymus was more prevalent in goitrous districts, that the literature had demonstrated a relationship between hyperplasia of the thymus and the thyroid disease, and that it had been conclusively demonstrated that ingestion of iodized salt by the residents of a specific goiter district lowered the incidence of thyroid enlargement in that particular section of the country. In view of these postulations and of the material available, we deemed it worth while to attempt to determine whether or not the use of iodized salt had any effect on the incidence of enlarged thymus.

In weighing comparisons of past and present figures on the incidence of thymic hyperplasia based on roentgenological findings, one must consider the criteria with which the roentgenologist formulated his determinations. Unfortunately, different observers have used somewhat different techniques in arriving at their conclusions —a fact which obviously makes comparison difficult.

Numerous observers have recorded the fact that the width of the upper mediastinal shadow is altered by exertion, crying, inspiration,[18,21,38] and heart beat. Kinney and Taylor,[25] after eight years' experience in the treatment of the thymus state that they have encountered enlarged thymus and atelectasis in 3 cases. Evans[14] makes the observation that the thymus lobe is larger on the affected side when it is found to be present in cases of unilateral atelectasis and that this may account for the failure of the lung to be properly aerated. Mulherin, Holmes and Harrell[34] conclude that the position of the diaphragm makes no difference, but Gerstenberger[16] thinks that the position of the diaphragm affects the width of the thymus shadow. Hasley and de Tomasi,[21] by means of a Jarre cin-ex camera, were able to obtain serial films to substantiate their claim that the thymus shadow changes size with breathing and heart cycle. Martin[31] expresses the opinion that the size of the thymus shadow has no relation to symptoms, and that the thymus is variable in size in the same infant at different times.

The pathologists and anatomists have established a normal weight and size for the thymus gland for the different age periods, having obtained their data from autopsies and cadavers. According to the figures of Hammar,[13] the average weight of the thymus in the newborn is 13.26 grams. The maximum size is placed at 26 grams and the minimum at 7 grams, which, as shown by Holt and Howland,[22] is 0.45 per cent of the body weight of the average newborn. The latter observers also show by a comparative table that this percentage of body weight exceeds that of any other period of life by 50 per cent. It would seem probable, then, that on a basis of percentage we would be likely to see by roentgen ray a fairly large group of enlarged thymuses in the newborn.

The physical signs of percussion and auscultation are not reliable for determining the presence of an enlarged thymus in instances where it is not tremendously enlarged. A clinical history of labored breathing, crowing sounds when crying and other recognized signs of an enlarged thymus are also not positive evidence, as other chest or laryngeal conditions may cause the same symptoms. Roentgenographic examination is the most reliable method of detecting an enlarged thymus.

However, no standard technique has been accepted. Review of the literature shows conflicting ideas on the methods of roentgenographing the patient and also in interpreting the normal. Some roentgenologists recommend that the films be made with the infant in the upright position;[43] others use an anteroposterior and posteroanterior view. Pancoast and Pendergrass,[39] Wasson,[47] Chamberlain,[6] Donaldson and Barnes,[12] and others, advise a routine lateral view, with the chin elevated and the patient on his side, irrespective of the other positions. This view is made in order to determine whether or not there is displacement, compression or buckling of the trachea and to demonstrate the thickness of the thymus. Pendergrass[40] and Barnett[1] feel that a combined roentgenoscopic and roentgenographic examination is essential for a correct diagnosis of enlargement of the thymus.

Coe[7] has devised a curve showing the relative size of the normal supracardiac shadow at various ages and sets a standard of 32 per cent of the transthoracic shadow as normal up to three months of age. Kinney and Taylor,[25] in a study of newborn babies, regard a mediastinal shadow of 3 cm. or less as normal. Carr,[5] in a study of two groups, sets the normal at 2.7 cm. in one group and 3.1 cm. at the level of the third thoracic vertebra in the second group. O'Brien[36] used Wasson's technique for examination and considered twice the width of the third dorsal vertebra as a minimum size for the abnormal. Shannon's[47] measurements of 219 infants at birth were made of the transverse diameter of the gland at the third dorsal vertebra and compared with the external chest measurements at this level in order to establish a

thymus chest ratio. In his study it was determined that the thymus shadow varied from 2.2 to 5.4 cm. in transverse diameter. The average in the first series of 100 cases was 3.2 cm. with a thymus chest ratio of 1:2.2 and in the second series of 119 cases the average transverse diameter was 3.44 cm. with a thymus chest ratio of 1:2.1. A comparison of the size of the thymus shadow in 33 newborn with those made three or four days later revealed a slight diminution of about 0.5 cm. Shannon also made a comparison of the size of the thymus in this series of newborn with that of 50 having thymus symptoms and noted no appreciable difference in size in the two groups.

It is conceded that an accurate and strict comparison of the published figures of incidence cannot be made because of the differences in methods and levels employed in measuring the transverse diameter of the thymus gland; in the point of centering the tube; in positions, whether anteroposterior or posteroanterior; and in the respiratory phases at which the exposure was made. In view, then, of the conflicting opinions as to whether or not there is a thymus problem, and of the variety of percentages of incidence arrived at by these many techniques and methods of establishing a normal, we began this report of a study of the chest of a series of newborn with a definite feeling of trepidation.

In this series of 1,455 cases, all of the newborn were examined in the same laboratory by the same staff of technicians, and a definite procedure was followed for a five-year period. All newborn were examined routinely at twenty-four hours after birth unless earlier examination was indicated by difficult breathing, cyanosis, or some special reason given by the attending obstetrician. Anteroposterior and lateral films were made in each case and re-examination made in those cases where the position was not satisfactory or where it was felt that additional films should be made in doubtful cases.

In the 1,455 cases examined from January, 1930, to January, 1935, there were 1,304 newborn chests and 151 older. Ages in the older group ranged from two weeks to five years, the majority being from two weeks to six months old. The films were taken from the files and reviewed by both of the writers. Three centimeters at the level of the third thoracic vertebra was considered the maximum width for a normal thymus shadow. For the group of borderline cases, from 3 to 3.5 cm. at the third thoracic vertebra was used as the criterion for classification. In the group showing positive thymus enlargement, a measurement greater than 3.5 cm. was used. No cases were classified as positive unless there was enlargement of the mediastinal shadow and evidence of narrowing of the trachea.

With this classification our results were as follows:

TABLE I

		Negative	Positive	Borderline	Percentage Abnormal
NEWBORN					
Female	613	502	69	42	18.1
Male	691	555	70	66	19.6
OLDER					
Female	66	59	4	3	10.6
Male	85	69	7	9	18.8

None of the older group was born in the hospital, all being referred for roentgen examination to determine whether or not thymic enlargement was present, either because of symptoms which the attending physician had attributed to enlarged thymus or because of the anxiety of parents who had had a former child with an enlarged thymus, or who knew of the existence of such a condition. No consideration was given to the weights of the newborn infants, and no effort was made in this study to determine if the preponderance of thymic enlargement was more common in the heavier babies.

Table II is a comparison of figures on the incidence of thymic hyperplasia taken from observations made in this locality up to 1935, including our present studies.

The procedure followed by Miller and Peterson[32] is as follows: Twenty infants were studied by means of roentgenoscopy, and for the rest the anteroposterior position was used. All exposures were made as nearly as possible at the end of expiration. For Hardy's[19] series the roentgenographic technique was not described, but it is gathered that only the anteroposterior views were made. Greenthal[17] does not state the position used, but Cooperstock remarks that recently the lateral view had been used in addition to the anteroposterior view. The technique of Donaldson and Barnes[12] is the same as that followed in the present series.

TABLE II

Author	Year	Number Examined	Percentage of Thymic Hyperplasia	
Peterson and Miller	1924	120	43.3	Newborn
Greenthal	1922	251	25.6	Older and newborn
Hardy	1924	20	50.0	Newborn
Cooperstock	1925–1929	352	21.3	Hare lip and cleft palate preoperative
Donaldson	1925–1928	500	20.4	Newborn
Present study	1930–1935	1,304	18.8	Newborn
		151	14.4	Older

It should be noted that the earlier observations were made prior to the institution of the use of iodized salt, and that in these earlier observations, even though the series reported is small, the incidence of thymic hyperplasia is relatively high in comparison with the present series.

If one could ignore the possible and known differences in the technique of roentgenographic examination and in the criteria for interpreting films, used and proposed by various investigators, it would be very interesting to make a comparison of our present series of thymic hyperplasia with series of cases reported in a distinctly non-goitrous belt. For example, from New York, Perkins[41] reported an incidence of 5 per cent of thymus in 500 children from one to two years of age in 1926. From Bellevue Hospital in 1928, Leech and Smith[27] reported thymic hyperplasia in 249 cases out of 4,000 autopsies, or an incidence of 6.2 per cent. These figures were apparently obtained from individuals of all ages. From Boston, Massachusetts, in 1929, Garland[15] reported that out of 1,564 autopsies, 23 individuals showed thymic enlargement, an incidence of approximately 1.5 per cent. Hudson,[23] of Boston, in 1935 reported no deaths due to thymic hypertrophy in some 16,000 children anesthetized without previous roentgen examination for enlarged thymus. Mosher, Macmillan and Motley,[33] in a clinical and preoperative study of the thymus in children of the tonsil and adenoid age, examined at the Massachusetts General Hospital 2,344 children varying from one year to sixteen years of age and found 7.5 per cent positive for enlarged thymus.

SUMMARY

We have presented a brief review of the literature to show the relationship of thyroid disease and thymic hyperplasia. It is evident from a review of other literature, that there has been a reduction in the incidence of simple goiter in the school children of Michigan since the introduction of iodized salt to the general populace in 1924. We have compared a series of roentgenograms of the thymus, taken before the introduction of iodized salt, with our present series of 1,455, of which 1,304 taken of newborn twenty-four hours after delivery showed an incidence of thymic enlargement of 18.8 per cent, and 151 taken of older children revealed an incidence of 14.4 per cent. This comparison indicates a decrease of approximately 55 per cent in

the incidence of thymic enlargement, as interpreted by roentgenographic examination, since the introduction of iodized salt.

CONCLUSIONS

These observations have demonstrated a general reduction of the incidence of thymic enlargement. We are unable to state as a scientific fact that this reduction is associated with a decrease in thyroid enlargement in Michigan, or whether it is due merely to different criteria of examination and interpretation. It appears quite evident, however, that we have not arrived at the place where the possibility of thymic death can be ignored. That this is true is indicated by the fact that in our own community many such deaths in untreated infants have been reported (in some the diagnosis has been confirmed by autopsy) within the past year.

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ROENTGENOLOGIC STUDIES OF THE LARGE BOWEL IN INFECTIONS BY *ENDAMOEBA HISTOLYTICA* BEFORE, DURING AND AFTER TREATMENT*

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DURING the past two and one-half years in a private office and private hospital practice, I have had an opportunity to examine the colons of 10 cases in which either the vegetative or cystic form of *Endamoeba histolytica* was demonstrated in the stools previous to or following my examination, together with 2 others having characteristic histories and roentgen findings in which it was impossible to demonstrate these organisms. Three of the above-mentioned cases were classified as so-called healthy carriers or as ones with very vague gastrointestinal symptoms with no history of dysentery but who harbored *Endamoeba histolytica* in the large bowel. One in which *Endamoeba histolytica* had been demonstrated in the stool one month previous to my examination had a lesion near the splenic flexure of the colon that was diagnosed and later proved to be a carcinoma. All the patient's symptoms could be accounted for by the carcinoma and the case was classified as a healthy carrier from the standpoint of amebiasis. One was classified as an acute amebic dysentery and the other 7 cases were considered to be chronic. All except the first 4 cases exhibited definite roentgenologic abnormalities in the large bowel that were considered to be the result of an amebic infection.

Of the 8 cases with demonstrable roentgen findings, all except 2 have been re-examined at frequent intervals during treatment and after clinical cure, in order to observe changes taking place as a result of antiamebic therapy. Six of these cases were reported by me[1] in the *Southern Medical Journal*, in 1936. In this communication the literature dealing directly with the roentgenologic phase of this problem was cited, the technical difficulties encountered in the examinations were discussed and some of the changes that had been noted before and during treatment were described.

The present paper will be limited to a report of 2 cases exhibiting lesions in the colons that could well have been mistaken for carcinoma and a third case of carcinoma in which the diagnosis was in doubt, due to the fact that the vegetative form of *Endamoeba histolytica* was present in the stool. An analysis of the changes demonstrated previous to and following antiamebic therapy will be included together with a brief discussion of the differential diagnosis between the so-called granulomatous type of amebic lesion and carcinoma.

CASE REPORTS

CASE 1. A white adult male entered the Norton Memorial Infirmary May 4, 1926, with a history of abdominal pain and temperature extending over a period of ten days. The temperature reached a maximum of 105°F. during this period. A roentgen examination was made May 10 which showed the right diaphragm to be elevated and the liver border to be about 5 cm. below the costal margin. An amebic infection of the liver was suspected although no organisms could be demonstrated in the stools, and emetine was given by mouth. Improvement was prompt and the patient was discharged ten days later clinically well. The diagnosis in the hospital record at that time was an amebic infection of the liver. He re-entered the same hospital July 7, 1927, because of an acute gallbladder infection. The gallbladder was removed and convalescence was prompt and uneventful.

The patient suffered from mild diabetes for years but was well otherwise until the fall of 1934 when he began to suffer from abdominal discomfort, a mild diarrhea, weakness and loss of weight. A proctoscopic examination was done elsewhere and a lesion of the rectum considered to be a carcinoma was demonstrated. A resec-

* Read at the Thirty-seventh Annual Meeting, American Roentgen Ray Society, Cleveland, Ohio, Sept. 29–Oct. 2, 1936.

tion was advised but the patient decided to return home for treatment. His physician here suspected that he was suffering from an amebic infection of the large bowel and not from a carcinoma. A proctoscopic examination was done and a microscopic examination of material removed showed numerous motile *Endamoeba histolytica*. The patient was then referred to my office for an examination of the colon. A barium enema showed marked irregular narrowing of all portions of the large bowel extending from the rectum to the cecum. The cecum was very small and irregular in contour and the barium flowed into the terminal ileum almost unobstructed. In the interpretation of the roentgen findings it was stated that changes such as those described above had been noted in individuals with chronic amebic dysentery and that it seemed probable that this disease was responsible for the abnormalities present. The following day after saline catharsis both the vegetative and cystic forms of *Endamoeba histolytica* were demonstrated. Antiamebic therapy was instituted and the patient made prompt recovery. He is clinically well at the present time but has not been re-examined due to the fact that he has failed to return as requested.

FIG. 1. Case I. Chronic amebic dysentery. Very poor illustration. Patient so uncomfortable that satisfactory exposure could not be made. Multiple irregular filling defects present in rectum, sigmoid and transverse colon. Almost complete absence of cecal pouch. Rapid escape of opaque material into terminal ileum.

FIG. 2. Case II. Chronic amebic dysentery. Sharply localized filling defect in distal part of transverse colon interpreted as localized amebic lesion. Cecum small and somewhat irregular. Rapid escape of barium into terminal ileum. Other portions of colon essentially normal.

CASE II. A white male adult was referred to my office for a gastrointestinal examination November 22, 1935, with a history of abdominal pain relieved by food, extending over a period of years. He also gave a history of an attack of acute diarrhea in February, 1935, which lasted for a period of ten days and was controlled with bismuth by mouth and other oral medication. During the attack the bowel movements were almost continuous and there was marked loss of weight. Following the attack the bowel moved only once a day but the stool was less well formed than had previously been the case. He failed to regain his normal weight after this attack and was under par in general but experienced no further diarrhea. He gave a history of having been in Chicago during the Century of Progress Exposition.

The roentgen examination showed a duodenal ulcer together with a large irregular filling defect in the distal third of the transverse colon that measured approximately 4 cm. in length, the appearance of which in many ways suggest-

Fig. 3. Case 11. Barium enema ten days after starting treatment. Filling defect in distal part of transverse colon had disappeared. Cecum was larger and more nearly regular than before. Less barium escaped into terminal ileum.

Fig. 4. Case 11. Serial films of cecum ten days after treatment was instituted showing constancy of the changes present.

Fig. 5. Case 11. Film of colon made after evacuation nine months after starting treatment showing apparently normal mucosal relief of the distal part of the transverse portion. Cecum is still small and somewhat irregular. Appendix is large and there is narrowing adjacent to the cecum.

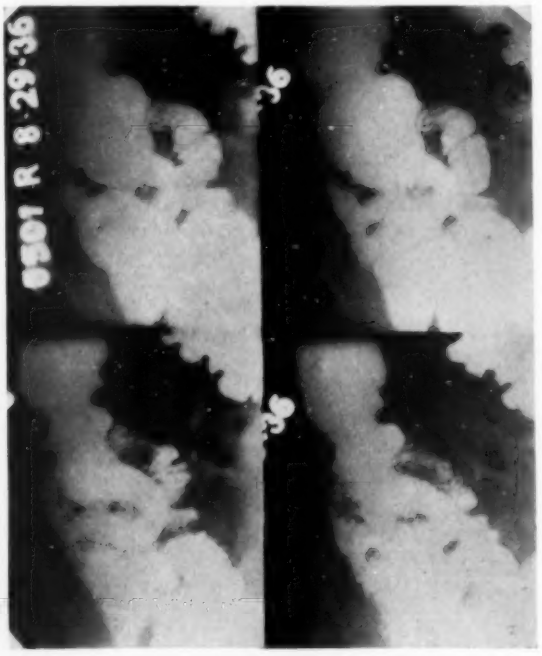

Fig. 6. Case 11. Serial films of the cecum made approximately nine months after treatment was instituted. Cecum still abnormal in shape and tone. Barium escaped rapidly into terminal ileum. Other portions of the colon were found to be normal.

ed a carcinoma. The lumen of the cecum was abnormally small, the outline irregular and a large amount of the opaque material was seen to escape into the terminal ileum. A diagnosis of chronic amebic dysentery with a granulomatous type of lesion in the transverse portion of the colon was made although I was not familiar with the patient's history at the time of the examination. The stool was examined November 22, 1935, and many motile *Endamoeba histolytica* were demonstrated.

Antiamebic therapy was instituted and ten days later an examination of the colon showed the lesion in the transverse portion to have disappeared. The lumen of the cecum was larger and less irregular than before but it was still definitely abnormal. A second series of treatments was then given. He was re-examined May 1, 1936, at which time all portions of the colon, aside from the cecum, were found to be normal. The lumen of the cecum was still smaller than normal, not entirely regular in contour and an unusual amount of opaque material escaped into the terminal ileum. An examination was again made August 29, 1936, and much the same findings were noted. The stool was negative for *Endamoeba histolytica* after the first series of treatments was given and has continued to be since that time. Regardless of this, it is my opinion that the cecum is still abnormal and that this patient cannot be considered cured although he is well from the clinical standpoint.

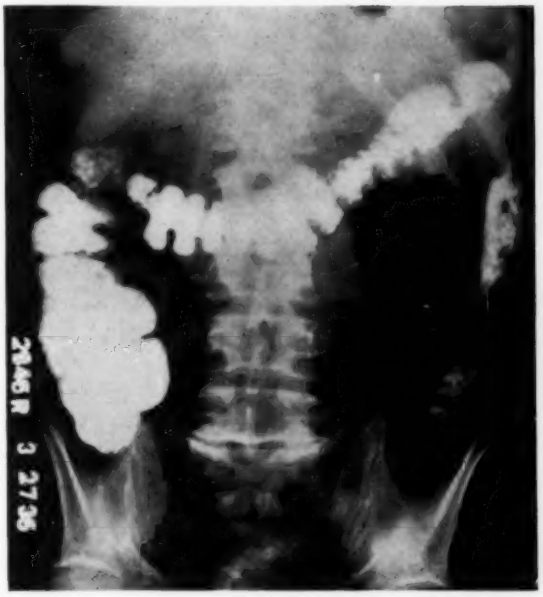

FIG. 7. Case III. Carcinoma near splenic flexure of colon shown after partial evacuation of enema. Defect was present throughout the roentgenoscopic examination. Cecum and ascending colon are normal. The vegetative form of *Endamoeba histolytica* was demonstrated in the stool one month prior to this examination. This organism had no apparent relationship to the lesion at the splenic flexure.

CASE III. A white male adult entered the Norton Memorial Infirmary March 23, 1936, with the following history. He had been well until December, 1935, when he developed an obstinate constipation associated with a sense of soreness in the epigastrium. Laxatives appeared to increase the abdominal discomfort. Early in February, 1936, the soreness seemed to localize in the left upper quadrant. He continued to work until the middle of February, 1936, when weakness and abdominal discomfort forced him to give up his activities. He visited a physician here in Louisville who had an examination of the stool made by a competent pathologist and numerous motile *Endamoeba histolytica* were found. The patient was then given antiamebic therapy over a period of one month. The therapy resulted in no relief of his constipation and the abdominal discomfort became more severe.

He also gave a history of having had "mucous colitis" in 1896 and 1897 and of having had typhoid in 1898. An appendectomy had been done in 1920. He had been well otherwise aside from the present illness.

When he entered the Infirmary March 24, 1936, his red blood count was 4,300,000 and the white blood count 9,700. Repeated stool examinations were made. They were negative for either the motile form or cysts of *Endamoeba histolytica*. Occult blood was demonstrated at each examination. A roentgen examination of the colon at this time showed a constant irregular stricture just proximal to the splenic flexure. The cecum and other portions of the colon were normal. In interpreting the findings at this examination it was stated that the lesion in the distal part of the transverse colon was evidently a carcinoma. Although *Endamoeba histolytica* had been demonstrated in the stool a month previous to my examination, it seemed that had the lesion been due to an amebic infection it would have responded promptly to therapy and would have been accompanied by abnormal changes in the cecum, neither of

which was the case. A laparotomy was done ten days later and a carcinoma of the splenic flexure of the colon was found and resected.

ANALYSIS OF ABNORMAL ROENTGEN FINDINGS NOTED IN THE CASES OBSERVED

The Cecum. The changes in the cecum have been characterized by irregular narrowing of the lumen, at times resembling a cone and at other times resembling a very small pouch. Where they were most marked the lumen was almost completely obliterated. Associated with this was an unusual degree of incompetence of the ileocecal valve. In many instances the barium enema flowed from the large bowel into the small bowel with no evidence of any hindrance whatever in the ileocecal region. The irregularity and deformity of the cecum above described were constant as was shown in serial films. In one case the patient was observed for a month before treatment was instituted and the only change in the cecum during this interval was an increase in the degree of deformity. The above abnormality of the cecum was found in 7 of the 8 cases where there was demonstrable pathology in any part of the colon considered to be the result of an amebic infection. Similar changes were likely present in the eighth case but the cecum could not be examined because of the irritability distal to it.

In 2 cases the demonstrable abnormalities in the large bowel were limited to the cecum. In both of these cases the histories were typical in that the patients had been in Chicago during the Century of Progress Exposition, had developed an acute dysentery after leaving there and responded promptly to antiamebic therapy. These were the only cases in which, at repeated careful examinations by a competent physician, it was impossible to demonstrate either the vegetative or cystic form of *Endamoeba histolytica* in the stool. In these two the diagnosis was based solely on the roentgen findings, the response to antiamebic therapy and the history.

Under treatment definite changes were noted in the deformity of the cecum in each case when first re-examined after therapy was instituted. These changes consisted of a decrease of the irregularity and an increase in the diameter of the lumen. At this same time contraction waves began to be noted in the cecum which were more or less rhythmic in character. These changes were seen to progress at each subsequent examination until the cecum became normal in outline and tone providing the treatment was adequate.

The Colon Aside from the Cecum. In the case classified as an acute amebic dysentery there was marked irregular narrowing of the lumen of the entire distal half of the colon. The proximal half could not be examined due to the marked irritability distal to it. The appearance was that of an acute ulcerative colitis with nothing suggesting the type except an irregular filling defect just proximal to the splenic flexure which was thought to be a so-called granulomatous amebic lesion. When examined one month after treatment was instituted the filling defect near the splenic flexure had disappeared, the tone of the colon in general was not increased and no evidence of ulceration could be seen. The patient was discharged from the hospital clinically well some three weeks later. She has not been re-examined due to the fact that she returned to her home in the eastern part of the United States.

The 7 cases classified as chronic amebic dysentery showed varying degrees of irregular narrowing of the lumen of the large bowel. In 2 cases the demonstrable abnormalities were limited to the cecum. All others with demonstrable irregularities in other parts of the colon showed changes in the cecum similar to the two above. There were irregular deformities in the transverse colon in all but 2 cases and similar changes in the rectum, sigmoid and descending colon in all but three. In many ways the abnormalities suggested the ordinary type of chronic ulcerative colitis aside from the changes in the cecum and the fact that the

bowel showed unusually marked irregular narrowing of the lumen in the parts involved. There was a tendency for the involvement to be less uniform than is the case in chronic ulcerative colitis in that abnormal segments of the bowel frequently had what appeared to be normal bowel between them. In one case the walls of the sigmoid were tremendously thickened forming an elongated mass at least 2 inches in diameter that could be grasped in the two hands and felt almost as hard as bone. When re-examined five months later the mass had disappeared and the distal third of the colon appeared to be normal in outline and tone.

In one individual in which the vegetative and cystic forms of *Endamoeba histolytica* had been demonstrated repeatedly, the changes seemed characteristic of a chronic ulcerative colitis of the ordinary type. The patient was acutely ill but under antiamebic therapy she improved markedly and the stool became negative for any form of *Endamoeba histolytica* and remained so when last examined. However, when she was examined a year after treatment was instituted the appearance of the colon was again that of a chronic ulcerative colitis. A proctoscopic and sigmoidoscopic examination was made at this time by a competent proctologist who considered the findings to be characteristic of a chronic ulcerative colitis of the ordinary type. Scrapings from the wall of the bowel at the time of this examination were negative for *Endamoeba histolytica*. In other cases, under therapy the bowel returned to normal very promptly and any suggestion of a chronic ulcerative colitis of the ordinary type disappeared. This did not take place in the above case although the stool became negative and the patient improved greatly. It is my opinion that there was a mixed infection in this individual and that she had both a chronic ulcerative colitis of the usual type and a chronic amebic dysentery as well.

AMEBIC GRANULOMAS

The term amebic granuloma, as I understand it, is applied to a localized more or less sharply circumscribed amebic infection in some part of the colon. In a lesion of this type there is marked thickening of the wall of the bowel usually underlying an ulcerated mucosa. Narrowing of the lumen takes place and may progress to complete obstruction. A readily palpable tumor mass is frequently present. These lesions manifest themselves in the roentgen examination as irregular filling defects in the bowel very similar to those of carcinoma. They become of importance when we consider the fact that quite a large percentage of individuals, even in the northern part of this country, harbor *Endamoeba histolytica* in the colon, although many do not exhibit clinical symptoms that can be attributed to this organism. One must bear in mind the fact that these individuals are subject to the same diseases as others who are free from this parasite, among them carcinoma. When such a lesion is found in the colon and *Endamoeba histolytica* demonstrated in the bowel content, the problem as to whether one is dealing with a carcinoma or an amebic granuloma then arises. Reed and Anderson,[2] in 1936, described 4 such cases. All gave definite histories of amebic infections and *Endamoeba histolytica* were demonstrated in the stools. A single lesion was present in the colon of each case which at first was thought to be amebic in nature. They did not change appreciably under treatment and resections later proved all of them to be carcinomatous in origin. It is of interest that the illustrations of Reed and Anderson's cases show the cecum to be normal in every case.

David and Loring[3] describe a case showing a filling defect in the transverse colon that resembled a carcinoma and was so diagnosed preoperatively. The lesion was resected and the microscopic diagnosis was a granulomatous ulcer of the colon. The Frei test was found to be strongly positive and a rectal stricture was present. A similar lesion developed in the descending colon later. The response to specific therapy was unsatisfactory and after a long illness the patient died. The authors' final opinion

was that "in all probability this patient suffered from an involvement of the rectum and colon with lymphogranuloma inguinale." The defect in the transverse colon in the illustration resembled closely a localized amebic lesion and the cecum, so far as could be determined, was somewhat deformed. Further experience with this disease may prove it to be a consideration in the differential diagnosis of localized amebic lesions of the colon.

COMMENT

The roentgenologic manifestations of amebic infections of the large bowel observed in my cases have been described previously by others. It is hoped that this report will aid in emphasizing the importance of the roentgen examination in this disease.

The type of deformity of the cecum found in these cases has not been observed in other diseases, with the possible exception of a relatively rare hyperplastic type of tuberculous infection of the cecum. The clinical and other laboratory findings should make it possible to differentiate these two conditions. The cecal changes have been so constant and so characteristic that, when found, it would seem that at least a strongly presumptive diagnosis of an amebic infection of the large bowel is justified, even if *Endamoeba histolytica* cannot be demonstrated in the stool.

The rapid return of the bowel to normal under adequate therapy has been striking. This evidently indicates that edema rather than actual destruction is a predominant factor in the pathology in many cases. It seems possible that in the tropics and in other regions, in cases of long standing, destruction followed by scar tissue formation may predominate and in these one would not expect the bowel to return to normal as have those above.

In the 2 cases in which the lesions were classified as of the granulomatous type, there was very prompt response to antiamebic therapy. At the first examination of each case after treatment was started the defect had disappeared, one examination being on the tenth day and the other after an interval of a month.

In the patients studied the roentgen findings have seemed to constitute a more satisfactory basis for determining the need of further therapy than have the stool examinations. The value of repeated examinations during and subsequent to antiamebic therapy may not be sufficiently appreciated by the majority of roentgenologists and other physicians as yet.

Only two of the granulomatous type of lesions were observed and one carcinoma with amebae in the stool, but it would seem that the following working hypothesis in cases such as these might be justified. If a lesion is demonstrated in the large bowel of an individual with *Endamoeba histolytica* in the stool which could be due either to a localized area of amebic involvement or a carcinoma, it is probably carcinomatous in nature providing the cecum does not show the deformity noted in the above cases. For further proof the patient should be given intensive antiamebic therapy and re-examined in from ten days to two weeks. Then if the defect is due to carcinoma, it is unlikely that there will be any appreciable change in the appearance following specific treatment, but if the result of an amebic infection there most certainly will be definite evidence of healing. However, if such a lesion is demonstrated and there is the type of deformity of the cecum above described, the lesion is likely amebic in nature even though it is impossible to demonstrate amebae in the stool, and a so-called therapeutic test followed by early re-examination is indicated.

SUMMARY

1. Definite roentgenologic changes in the colon have been found in all cases of acute or chronic amebic dysentery studied.

2. The deformity of the cecum has been the most constant and most characteristic change noted.

3. The diagnosis in two cases was based almost entirely on the roentgen findings

and the histories. The response to therapy attested to the accuracy of the diagnosis in each case.

4. The roentgen examination is of decided importance in following the progress of the patient during and subsequent to treatment.

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DISCUSSION

Dr. Harry M. Weber, Rochester, Minn. Dr. Bell's presentation of cases is timely and most instructive, because in presenting them he emphasizes that roentgenologic methods have an important contribution to make to the diagnosis of colitis caused by *Endamoeba histolytica*, and this contribution has been neglected, for the most part, in the past.

One is impressed, on looking through the clinical literature on amebiasis, with the frequency with which the roentgenologic diagnostic possibilities are minimized with words equivalent to these: "Roentgenologic methods have little to offer in the diagnosis of intestinal infection with *Endamoeba histolytica*." Dr. Bell emphasizes again that when the pathologic changes produced in the course of this infection are extensive enough, roentgenologic methods can be made to present reliable and sometimes striking evidence of such changes.

Craig insists that the demonstration of *Endamoeba histolytica* in the stool means that an amebic intestinal lesion exists, and that this lesion is their source. It may indeed be small and not recognizable at the macroscopic examination of the intestine. If so, it is not reasonable to expect that roentgenologic methods will disclose it. After all, a lesion must reach macroscopic proportions if it is to be demonstrated by roentgenologic methods, in their present stage of refinement.

About 30 per cent of the carriers of *Endamoeba histolytica* seem to fail to have roentgenologically demonstrable lesions in the colon. About 50 per cent of the carriers may be expected to have amebic ulcers in the rectum which can be visualized at the proctoscopic examination and which the experienced proctoscopist can recognize as amebic ulcers. In practically all instances of amebiasis when rectal or sigmoidal ulcers are found, roentgenologic evidence of amebic colitis, such as that presented by Dr. Bell, is elicitable.

I want to say a word about patency of the ileocecal valve and its significance in this connection. It is almost always possible to visualize the terminal segments of the ileum by filling them with contrast material in retrograde direction through the ileocecal valve. This, in fact, is the final maneuver in the roentgenologic examination of the colon using the contrast enema. Normally a short interval of time elapses between the arrival of the contrast suspension at the level of the ileocecal valve and its actual entry into the ileal lumen. Often considerable manipulation of the ileocecal intestinal segment is required before ileal filling takes place. This might be designated as normal ileocecal patency. In pathologic ileocecal patency, however, there is no halt; the contrast suspension rushes into the ileal lumen entirely unimpeded, and this is construed as evidence of ulceration and inflammation of the ileocecal structure. It is not difficult to differentiate between normal and pathologic ileocecal patency.

It seems opportune to urge closer cooperation between clinician, proctoscopist and roentgenologist in the management of amebiasis, for with accumulation of experience an even more valuable contribution can, I feel certain, be expected from roentgenologic methods.

Dr. James T. Case, Chicago. Dr Bell has called attention to the asymmetry of the diaphragm in some cases of amebic infection of the bowel. I should like to emphasize a sign relative to the diaphragm which has been worked out in the Passavant Hospital in Chicago in connection with the service of Dr. Charles A. Elliott. There have been a number of cases in which amebic infection was suspected but in which the definite proof was lacking, but where the patient had febrile and other manifestations, together with pain in the right upper quadrant and uncertain bowel dysfunction, which led to the strong suspicion of amebic infection without definite proof. In these cases it was discovered in a series of observations that the diaphragm on the right side became progressively less free in its excursion, and finally

in some cases became fixed. In one of these cases where the diaphragm failed to move on respiration the case went on to definite recognition of amebic abscess in the liver and operation; but after that experience the sign was recognized in a number of cases which were subjected to the classical treatment for amebic infection, and there was seen a gradual freedom, increase in excursion of the diaphragm on that side, coincident with the progression of the cure. I think it is wise to bear in mind that is a sign which may help in some of these cases.

Dr. E. C. Samuel, New Orleans. I presume that we see in New Orleans about as much amebic dysentery as is seen anywhere in the United States. In our extensive work with the late Dr. S. K. Simon and at the present time with Dr. D. N. Silverman, who probably treated more cases of amebic dysentery than any one else in the United States, we were never able to show any difference between the colon infected with the Shiga or Flexner bacillus or an ameba. I mention this as a word of advice and warning to you.

Dr. Bell (closing). In most cases I do not believe it is possible to differentiate acute amebic dysentery from other forms of acute dysentery. This is due, in part at least, to the marked irritability of the bowel usually present which prevents satisfactory filling. The roentgenologist will seldom see these cases and roentgen examination is not of importance in establishing the diagnosis. In the cases that I have classified as subacute and chronic, however, there have been variations from the normal that were common to all. These have appeared sufficiently characteristic to justify at least a strongly presumptive diagnosis of amebiasis. Such changes may not take place in the tropics or in the southern section of our country but this seems unlikely.

Vol. 39, No. 6

ROENTGENOLOGICAL DIAGNOSIS OF VOLVULUS OF SIGMOID MEGACOLON

WITH REPORT OF TWO CASES

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THE ABSENCE in the literature of the roentgenological findings by means of barium enema, in cases of volvulus of megasigmoid, has prompted us to report the following 2 cases:

REPORT OF CASES

CASE 1. G. P., male, aged forty-six, was admitted to the hospital with chief complaint of pain in abdomen. He had been in his usual good health until five days previously when he failed to have his usual daily bowel movement. He had not had a bowel movement in five days. The administration of large doses of cathartics together with enemata failed to relieve this condition. There were lower abdominal pains over a period of twenty-four hours previous to admission. There was no past history of constipation.

Patient did not appear acutely ill. The abdomen was markedly distended. No palpable tumor mass was present in the abdomen. Temperature was 98.9°F.; pulse 80.

A provisional diagnosis of large bowel obstruction was made.

Roentgen Findings. Under the fluoroscopic screen the enema fluid was seen to readily fill the dilated colon, which was lying in the right abdomen, with apparently little discomfort to the patient. The patient was unable to evacuate the contents of the dilated sigmoid. Films taken after the barium enema show dilated loop of sigmoid in the right abdomen with absence of infiltrative lesion distal to dilatation. The post-evacuation film disclosed the dilated loop re-

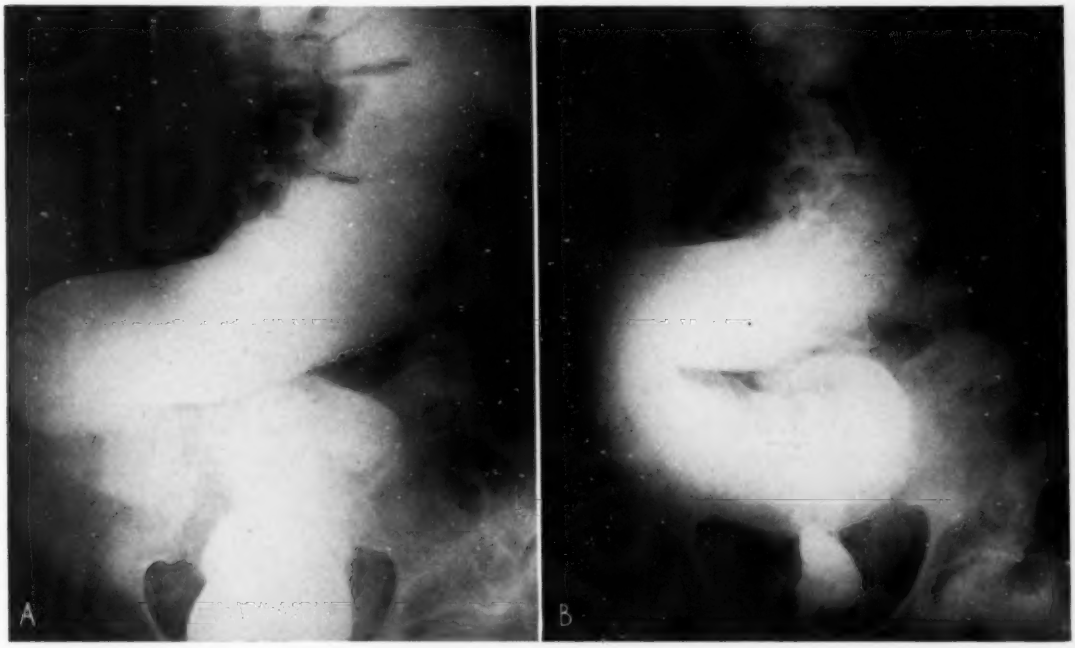

FIG. 1. Case 1. *A*, roentgenogram taken after barium enema shows dilated sigmoid loop in right abdomen, with absence of infiltrative lesion distal to dilatation; *B*, post-evacuation roentgenogram shows sigmoid loop retaining enema fluid injected, with colon distal empty and presenting normal mucosal pattern.

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taining the opaque enema fluid. The colon distal to the dilatation is empty with normal mucosal pattern. Diagnosis of volvulus of megasigmoid was made.

Operative Findings. Right rectus exploratory incision was made. An enormous edematous thick-walled sigmoid was found measuring 20 inches in circumference. Volvulus was present. The sigmoid was twisted around its base in clockwise direction through 180°. The volvulus was undone and a rectal tube passed. A small amount of gas, fecal material and barium passed. The bowel deflated and slowly regained some tone. A split muscle incision was then made in the left flank and a loop of sigmoid was drawn out and stitched on skin over a glass rod. There still appeared to be obstruction and three days later a cecostomy was done. Eight days later, the incision tore open. The incision was closed again after replacing the extruded bowel. Symptoms of obstruction persisted.

The patient died three weeks after the onset of symptoms, probably from ileus. Autopsy revealed acute fibrinous, purulent peritonitis about the exploratory incision with generalized low grade fibrinous peritonitis. There was also bilateral aspiration pneumonia. No notation was made as to the condition of the sigmoid.

CASE II. R. P., male, aged sixty-four, was admitted to the hospital with chief complaint of pain in the abdomen for two days. His bowels had not moved for five days prior to admission while there was a past history of constipation throughout life. There was nausea and vomiting on the day of admission to hospital. There was no history of the patient passing blood or mucus by rectum.

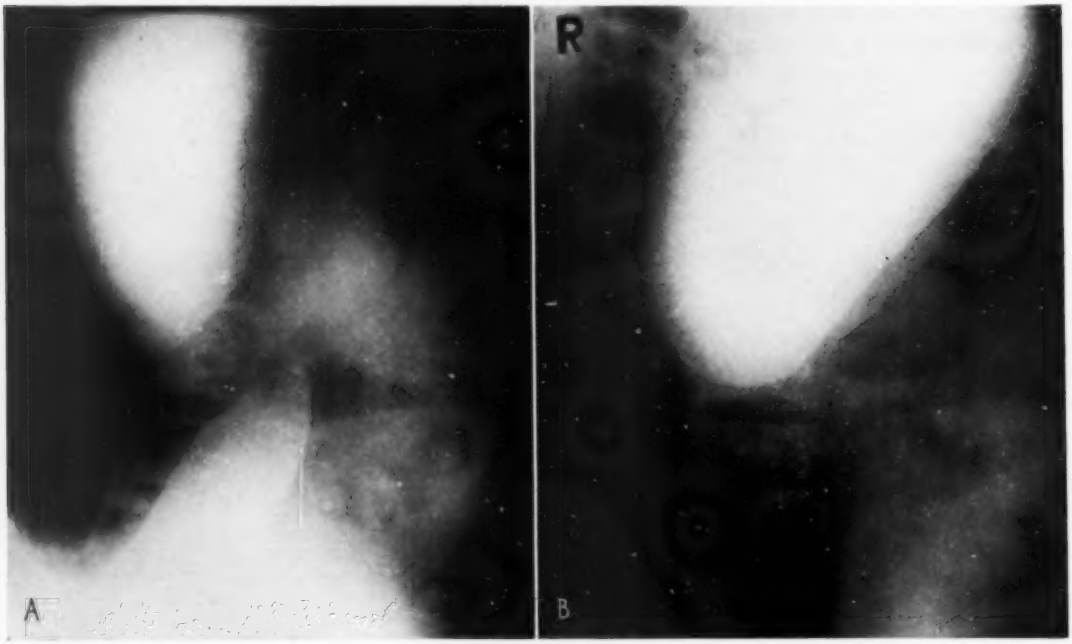

FIG. 2. Case II. *A*, roentgenogram taken after barium enema shows dilated sigmoid lying in right abdomen, with compression of lower sigmoid due to rotation. There is no evidence of infiltrative lesion; *B*, post-evacuation film shows dilated loop of sigmoid retaining all of opaque material injected, with colon distal to obstruction empty, and presenting normal mucosal pattern.

On physical examination the patient appeared acutely ill. The abdomen was markedly distended but no tumor mass was felt. Temperature 99°F.; pulse 80. A single film of the abdomen taken in the posteroanterior direction showed a markedly dilated loop of large bowel running longitudinally throughout the length of the abdomen in and to the right of its midline.

Roentgen Findings. Under the fluoroscopic screen the enema fluid was seen to outline a normal rectum and distal sigmoid. It then flowed freely into a large dilated loop of colon lying in and to the right of the midline of the abdomen. There was no apparent distress to

the patient. The retained colonic content within the loop diluted the clysma and rendered it less opaque. Screen examination after the patient attempted to evacuate showed a distended loop of sigmoid retaining the enema with the distal sigmoid and rectum empty. Roentgenograms taken after the barium enema showed a markedly dilated loop of sigmoid outlined by barium and traversing almost the full length of the abdomen in and to the right of the midline. There was no evidence of an infiltrative lesion at the distal portion of the distended colon. The rectum and distal sigmoid were normal. The post-evacuation film presented the enlarged sigmoid retaining the opaque material. A normal mucosal pattern was seen distal to the dilatation. A diagnosis of volvulus was made.

Operative Findings. A left rectus incision was made. A huge dilated sigmoid presented itself about 4 feet in length and 5 inches in diameter. Volvulus was found. The sigmoid was twisted on itself through about 270°. There was definite interference with the blood supply. The incision had to be extended almost to the unciform cartilage in order to lift out this huge distended loop and untwist it. A rectal tube was then passed and the major portion of the dilated sigmoid was emptied. It was then possible to close the abdomen without difficulty. There did not seem to be any reasonable way of fixing the sigmoid to prevent a similar occurrence in the future. Any operation done would necessitate the removal of the entire loop and the patient's condition would not permit such an operation. The abdomen was closed without drainage. The patient made a satisfactory recovery. There was no history of recurrence.

Patient died two and one-half years later from coronary disease; there was no autopsy.

Sixty-nine cases of volvulus of sigmoid megacolon have been found in the literature. In only 4 patients was a diagnosis of volvulus made by means of roentgen examination. The condition is twice as common in males as in females, while nearly 50 per cent of the cases occurred in individuals between forty and sixty years of age.

The etiology of megacolon is not known. Many theories have been propounded. Chronic volvulus due to long megasigmoid and eventually causing hypertrophy is one theory.

The roentgen findings in the 2 cases reported here were identical, as can be seen in the illustrations. The picture could not be mistaken for that of any other pathological entity. The giving of the enemas did not, in my opinion, harm the patients. Both required immediate operation because of obstruction. When the volvulus was undone, the dilated loop was readily emptied of its contents by passing a rectal tube. Moreover, in both cases it was particularly noted how little discomfort was given the patients by the administration of the enema. The diagnosis made by means of the barium enema acquainted the surgeon with the abdominal condition he had to deal with.

The roentgen diagnosis by means of barium enema depends on the following points: (1) tremendously dilated sigmoid situated in the right abdomen; (2) valve-like obstruction distal to the dilatation which allows free entry of enema fluid and yet prevents the patient from evacuating contents from distended loop; (3) normal mucosal pattern in sigmoid and rectum distal to dilated loop.

I am indebted for Case 1 to Dr. Stuart Gordon of the Surgical Staff of the University of Toronto, and for Case 11 to Dr. J. A. MacFarlane, of the Surgical Staff of the University of Toronto.

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ROENTGEN DIAGNOSIS OF HEPATODIAPHRAGMATIC INTERPOSITION OF THE LARGE INTESTINE*

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UNDER the name of hepatodiaphragmatic interposition a condition is described in which a portion of the large intestine is located above the liver, directly under the right dome of the diaphragm. This position of the intestine is abnormal, the upper surface of the liver being, as a rule, adjacent to the dome of the diaphragm. In the normal state there is an intensive homogeneous darkening on the screen below the right dome of the diaphragm, which is due to the greater density of hepatic tissue as compared with that of surrounding organs. However, in the case of the interposition when this section of the intestine is filled with gas, a distinct transparency is seen upon the screen, and not infrequently the haustra of the large intestine can be distinguished. The size of the gaseous layer, in interposition, varies greatly within broad limits and depends upon the degree of the filling of the intestine with gas. The distended intestine displaces the liver downwards and to the median line. In order to prove that it is really a loop of the large intestine, one has only to fill the intestine with a contrast enema, and show its relation to the liver and diaphragm. Chilaiditi was the first, in 1910, to call attention to this abnormal position of the large intestine. A number of subsequent writers (Schittenhelm, Uspensky, Podkaminsky, Trémolières and Pierron, and others) described this phenomenon more in detail, pointing out a series of characteristics common to persons having these anomalies. But despite their studies the etiology, and especially the clinical value of the interposition, cannot be considered as absolutely clear. Sometimes a general practitioner is not very familiar with this condition, so that in examining his patient he may very often forget that this abnormal state does exist. It should be noted, however, that the roentgen diagnosis of the interposition is accurate and that, for the time being, the diagnosis of this condition can be exclusively roentgenological.

The opinions of writers who have described hepatodiaphragmatic interposition differ as to the real causes of its origin. Chilaiditi believes that the principal cause lies in the ptosis of the liver owing to the weakness of the connective apparatus as well as in atony of abdominal walls. In contradistinction to this opinion, Bürger and others consider the connective apparatus of the liver as of little value in holding it in place; they state that owing to gravity the liver cannot be held by the ligaments and in the main it lies, as it were, upon a sort of a pad formed by the intestine and is kept in place by intra-abdominal pressure. The ligaments only support the liver. To prove this, they point out that when the intra-abdominal pressure is changed, as is the case in pneumoperitoneum, the liver does not remain in place and then, on the roentgenogram, between the upper border of the liver and the dome of the diaphragm the gaseous layer can be distinctly seen. The shape of the chest and the condition of the tonus of diaphragm are likely to play a certain rôle here. The loss of the elasticity of pulmonary tissue, as well as the alteration of the tonus of diaphragm, has been noted by some writers (Podkaminsky, Kaiser and others) as factors predisposing to interposition of the large intestine because the suction power of the lungs decreases and the liver falls. Coalescences between the liver and pyloric portion of the stomach or duodenum may also contribute

* Translated from the Russian by Alexis A. Sheremetefsky.

to the displacement of the liver to the median line and downward. Laurell points to atrophy of the liver as one of the causes of the interposition. As a result, the sections of the intestine which, by virtue of the irregular development of the intestine itself or mesentery possess an abnormal mobility, may be rather readily wedged between the liver and diaphragm.

As to their duration, the interpositions may be divided into permanent and temporary, the latter being the more common form. In these cases, when roentgenoscopy is repeatedly performed the liver is sometimes seen to occupy its usual place just below the dome of the diaphragm. The differential diagnosis includes an artificial or spontaneous pneumoperitoneum and subdiaphragmatic abscess. In the former case, there is a bilateral narrow layer of air below the domes of the diaphragm, which is displaced when the patient changes his posture; the history of disease is very characteristic in such cases; haustration which is so suggestive and constant in cases of interposition is absent. In the case of subdiaphragmatic abscess there is a comparatively small bubble surrounded by increased density and sometimes a partial upward bulging of the diaphragm; the clinical picture and history are also characteristic.

We have been unable to find in the literature available any indications as to the influence of sex, age and occupation on the formation of hepatodiaphragmatic interposition.

In the following will be given some of our observations on hepatodiaphragmatic interposition which have been collected in our practice during the last five years.

Out of 20,000 roentgenoscopies in the Roentgenological Department of the Physio-Therapeutic Institute we have observed 29 patients with hepatodiaphragmatic interposition of large intestine. The following are some data from their case histories:

REPORT OF CASES

Case I. P. M., aged thirty-six, tailor; had suffered from recurrent typhus, typhus and typhoid fever. Fracture of right clavicle and hip. Complains of pains in the right arm and in the subcostal region. Diagnosis: gastric catarrh, and traumatic neuritis. Roentgenoscopy: complete hepatodiaphragmatic interposition of the large intestine, temporary form.

Case II. D. E., aged sixty, wagoner. Had suffered from typhus. He had contusions of chest and lower limbs (crushed by a falling rock). At the age of thirty, hard chancre. Wassermann reaction negative. Complains of shortness of breath and pains in the substernal region. Diagnosis: emphysema of lungs, aortitis, and degeneration of cardiac muscle. Roentgenoscopy: partial interposition of large intestine, temporary form.

Case III. S. E., aged twenty-eight, tailor. Suffered from malaria and gonorrhea. Complains of pains in the right substernal and subcostal region; cannot sleep on the right side. Shortness of breath and rapid fatigue at physical labor. Constipation for two to three days. Referred for roentgenoscopy on account of pulmonary tuberculosis. Roentgenoscopy: fibrous form of tuberculosis of lungs, complete interposition of large intestine, temporary form.

Case IV. L. P., aged thirty-eight, official. Complains of pains in the region of stomach, as well as of shortness of breath. Diagnosis: neurasthenia. Roentgenoscopy: complete interposition of large intestine, permanent form.

Case V. P. A., aged forty-two, worker. Suffered from recurring fever. Had hard chancre at age of twenty-seven. Complains of pains, in the morning, in the region of the heart with radiation to the right arm. Diagnosis: defect of aortic valve, aortitis. Roentgenoscopy: complete interposition of large intestine, permanent form.

Case VI. O. E., aged forty-eight, peasant. Complains of pressure in the substernal and right subcostal region. Constipation for two to three days; nausea. Gastric juice: general acidity, 16; free HCl, 0; reaction to blood, positive. Diagnosis: gastric ulcer. Roentgenoscopy: partial interposition of large intestine, gastric ulcer.

Case VII. B. N., aged sixty-eight, smith, in trade since age of fourteen. Complains of pains in the abdominal region; constipation for two

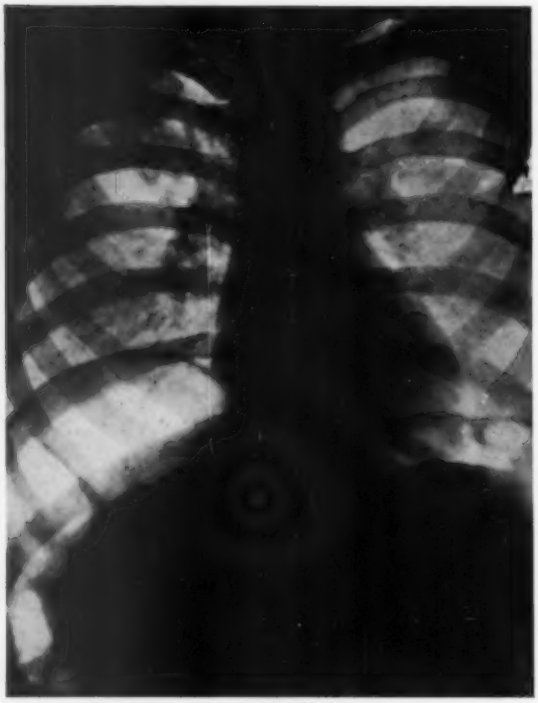

FIG. 1. Case XV. Roentgenogram showing complete interposition of the large intestine.

to three days. Shortness of breath and pains in the substernal region, especially on bending. Diagnosis: emphysema of lungs, aortitis, colitis, prolapse of stomach. Roentgenoscopy: emphysema of lungs, complete interposition of large intestine, permanent form.

CASE VIII. N. B., aged fifty-two, peasant. Suffered from measles and recurring fever. Complains of severe coughing, shortness of breath and impossibility of swallowing. Admitted to Oncological Department with diagnosis of carcinoma of larynx, emphysema of lungs and arteriosclerosis. Roentgenoscopy: complete interposition of large intestine, temporary form. In a fortnight, died from cardiac debility. Extract of record of autopsy (performed by Docent P. M. Nagorsky): lungs do not collapse, in places coalesce with thorax and diaphragm, more on the right side. Lungs accessible to air. Parietal and visceral peritoneum pale and humid. Diaphragm on right and left at the level of the sixth rib. Liver at the axillary line protrudes from under the edge of rib to 5 cm. The ligament situated in front between diaphragm and liver is quite transparent, 1 mm. thick.

There is no coalescence of liver with diaphragm. The colon, from the region of the right kidney to that of the spleen, is 60 cm. long; in its length there are two narrowings, each 2 cm. long, 6 cm. apart. No coalescence of large intestine with adjacent organs. Pathologico-anatomical diagnosis: carcinoma of larynx, swallowing pneumonia, chronic adhesive pleuritis, parenchymatous degeneration of organs and general emaciation.

CASE IX. G. V., aged thirty-one, worker. Suffered from recurring fever. Had had contusion in the war and trauma (was run over by a wagon). After trauma was in hospital for one month. Complains of persistent constipation, sometimes for five to six days. Diagnosis: traumatic neurosis, atony of intestine. When in the hospital, had normal stool only two times during one month and a half. Roentgenoscopy: complete interposition of large intestine, permanent form.

CASE X. E. J., aged thirty-two, loader. Began to work as a laborer at age of eight. Complains of heartburn, swelling of abdomen and constipation. Diagnosis: defect of mitral valve, acid catarrh of stomach. Roentgenoscopy: complete interposition of large intestine, permanent form.

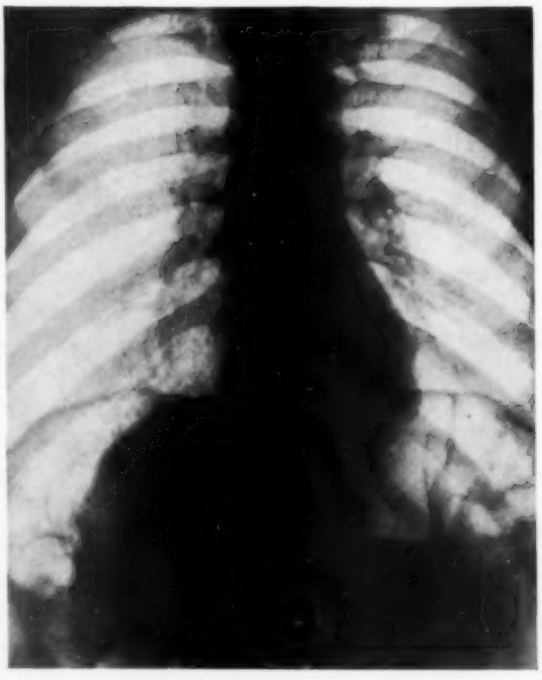

FIG. 2. Case XXV. Roentgenogram showing partial interposition of the large intestine, permanent form.

Case xi. P. V., aged twenty-seven, teacher. Suffered from typhus. Complains of headaches, growth of limbs, constipation. Diagnosis: acromegaly. Roentgenoscopy: complete interposition of large intestine, temporary form.

Case xii. K., aged fifty-two, worker. Complains of sharp pains in the region of stomach, of nausea and vomiting. Diagnosis: cancer of stomach. Roentgenoscopy: filling defect in the pyloric portion of stomach; painful on palpation. Tumor of stomach (cancer), partial interposition of large intestine. Operation: Tumor could not be removed owing to extension. Death in eight days. Brief data from the record of autopsy (performed by Docent P. M. Nagorsky): In the abdominal cavity 500 cc. of grayish liquid. Stomach coalesced with pancreas and slightly distended by gases; there is a stoma with the first loop of small intestine, the sutures firm.

The lesser curvature of stomach and its lateral side, turned to the spinal cord, is hard and coalesced with pancreas, and partially with liver. In the midportion of the lesser curvature there is an ulcer 2.5 cm. in diameter with smooth hard edges. The base of the ulcer is thick, nodular and coalesced with the pancreas. Duodenum not accessible (ligated). Liver coalesced with diaphragm, flabby, of clayish tint. Pancreas in its upper portion is full of metastases; atrophy of tissue of the gland. Mucosa of small and large intestine pale, swollen and covered with mucus. Diagnosis: ulcer of stomach undergoing cancerous degenerations.

Case xiii. K. D., aged thirty-four, peasant. Complains of pain in substernal region, nausea. Diagnosis: acid catarrh of stomach. Roentgenoscopy: partial interposition of large intestine, temporary form.

Case xiv. D. J., aged fifty-one, storekeeper. Fell from scaffolding; had a fracture of clavicle and contusion of the right side. Was treated for six months. Patient notes that constipation appeared after contusion. Complains of pain in substernal region; sometimes nausea and vomiting. Diagnosis: cancer of stomach. Roentgenoscopy: filling defect in the pyloric portion, cancer of stomach, partial interposition of large intestine, permanent form.

Case xv. B. V., aged twenty-nine, teacher. Complains of weakening of memory and pain

Fig. 3. Case ix. Roentgenogram taken in vertical position showing the large intestine filled with contrast medium.

when swallowing. Diagnosis: neurasthenia, tuberculosis of lungs and larynx. Roentgenoscopy: productive form of pulmonary tuberculosis, complete interposition of large intestine.

Case xvi. A. S., female, aged thirty-eight, peasant. History of pulmonary bleeding. Complains of pain in chest, shortness of breath and coughing. Diagnosis: active tuberculosis of lungs. Roentgenoscopy: cavities in the right subclavicular region, partial interposition of large intestine.

Case xvii. Sh. J., aged thirty-one, peasant. Suffered from typhus, smallpox and has undergone an operation of hernia of linea alba. Contusion of the chest when falling from a horse. Complains of pains in substernal region and lower portion of the thorax. Constipation for three to four days. Diagnosis: catarrh of stomach. Roentgenoscopy: partial interposition of large intestine.

Case xviii. G. M., aged sixty, housewife. Suffered from gastric pain for one year. Complains of nausea, vomiting, pain in substernal region. Diagnosis: cancer of stomach. Roent-

genoscopy: cancer of stomach, partial interposition of large intestine.

CASE XIX. F. J., aged thirty-six, peasant. Suffered from typhus. Complains of pain in lower part of the thorax on the right; shortness of breath, and coughing. Diagnosis: acid catarrh of stomach. Roentgenoscopy: partial interposition of large intestine.

CASE XX. J. F., aged forty-nine, worker. Suffered from malaria and contusion of the back (twice). Complains of shortness of breath, coughing, pains in arms and legs. Liver enlarged and painful on palpation. Diagnosis: catarrh of stomach, chronic polyarthritis and hepatitis. Roentgenoscopy: partial interposition of large intestine, permanent form.

CASE XXI. M. L., aged forty-six, peasant. Complains of pains in substernal and right subcostal region, of nausea and vomiting. Diagnosis: achylia of stomach, emphysema of lungs. Roentgenoscopy: partial interposition of large intestine, permanent form.

CASE XXII. J. A., aged forty-five, peasant. Pains in the chest more to the left; after meals pressure in stomach. Diagnosis: acid catarrh of stomach. Roentgenoscopy: partial interposition of large intestine, permanent form.

CASE XXIII. N. L., aged fifty-five, peasant. Eighteen months before had contusion of spine and right side (falling from horse). Complains of pains in loins and substernal region. Sometimes nausea, swelling and pressure in the region of stomach. Diagnosis: gastritis. Roentgenoscopy: partial interposition of large intestine, permanent form.

CASE XXIV. X, aged forty-two, official. Complains of pains in chest. Diagnosis: pulmonary tuberculosis (?). Roentgenoscopy: partial interposition of large intestine, temporary form.

CASE XXV. M. P., aged fifty-five, carpenter. Has worked since age of fourteen. Suffered from typhus in 1916; in 1918 fell from scaffolding, and could not work for one and a half months. Complains of pain in legs; coughing, shortness of breath and incontinence of urine. Diagnosis: general arteriosclerosis, emphysema of lungs. Roentgenoscopy: partial interposition of large intestine, permanent form.

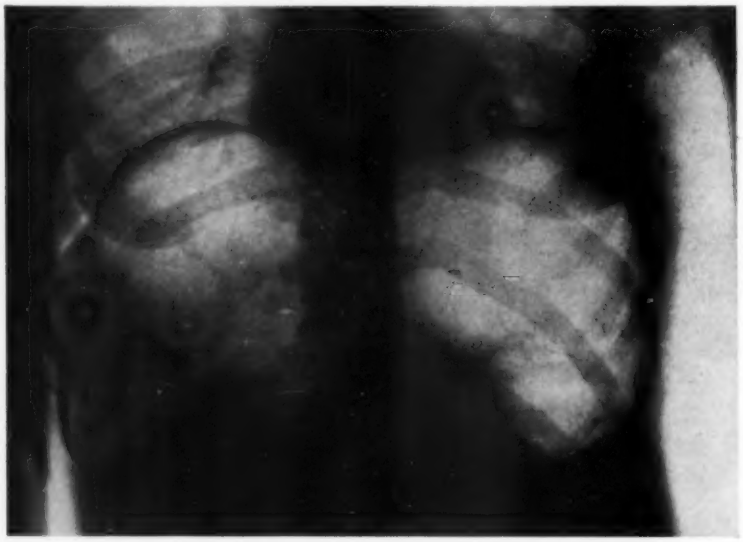

FIG. 4. Case XXIX. Roentgenogram showing complete interposition of the large intestine, permanent form; liver displaced downwards and laterally.

CASE XXVI. B. J., aged fifty-four, miner. Has worked since age of fifteen. In 1926 he was crushed by rock in a pit, after which he was in the hospital for one month. Complains of pains in the region of stomach, in the region of liver, and of incontinence of urine. Diagnosis: general arteriosclerosis, degeneration of the cardiac muscles and catarrh of stomach. Roentgenoscopy: partial interposition of large intestine, permanent form.

Case xxvii. K. J., aged fifty, locksmith for about thirty-five years. In 1906 and 1918 was violently beaten, struck on head and back. Complains of headaches, constipation, pain in stomach after meals. Diagnosis: general arteriosclerosis, aortitis, catarrh of stomach. Roentgenoscopy: partial interposition of large intestine, permanent form.

Case xxviii. D. J., aged sixty-five, official. Suffered from typhus and disease of liver; inguinal hernia. Complains of pain in the region of liver and frequent urination. Diagnosis: diabetes melitus, general arteriosclerosis, inguinal hernia. Roentgenoscopy: partial interposition of large intestine, permanent form.

Case xxix. V. A., aged thirty-one, nurse. In 1926, after delivery, suffered from ovaritis and peritonitis. Complains of swelling of intestine, pressure in substernal region, constipation and pain in the lower portion of abdomen. Diagnosis: adhesive peritonitis, parametritis. Roentgenoscopy: complete interposition of large intestine, permanent form, with displacement of liver downward and laterally.

There were among the 29 above cases, 19 outpatients and 10 hospital patients; 25 males and 4 females. The age of the patients varied from twenty-seven to sixty-eight years, viz: 27–30, 4 cases; 30–40, 10 cases; 40–50, 5 cases; 50–60, 8 cases, and above 60 years 2 cases. Thus, the interposition of the large intestine was found more often in males, 30–60 years of age. Social position: peasants, 10; workers, 11; officials, 5; craftsmen (tailors), 2, and one housewife.

In all of our cases the interposition was an incidental finding during roentgenoscopy, for the patients were referred to the roentgenological Department with various other diagnoses. With regard to the condition for which the patients were sent to the Roentgenological Department, our cases may be divided into several groups. The largest group comprises 16 cases suffering from diseases of the gastrointestinal tract; to the second group—the minor one—may be referred patients suffering from affections of the cardiovascular system and lungs; these are 8 in number. The diagnoses in all other cases were as follows: neurasthenia, acromegaly, traumatic neuritis, carcinoma of larynx and chronic adhesive peritonitis. In the group comprising persons suffering from gastrointestinal diseases there were 3 cases with tumor of the stomach (cancer), 9 cases of catarrh of the stomach and 2 cases of gastric ulcer.

Among the chest affections there were 3 cases of active pulmonary tuberculosis with tubercle bacilli, and 5 cases of emphysema of the lungs. Moreover, as a concomitant condition chronic bronchitis has been found in some of our patients. Among the cardiovascular affections there were 2 cases of syphilitic aortitis and 2 cases of valvular disease. Arteriosclerosis was found in 5 cases.

As a result, we are able to state that the interposition of the large intestine most frequently occurs in patients suffering from diseases of the gastrointestinal tract.

As to the complaints of our patients, in the vast majority of cases they can be reduced to pain in substernal region and in the lower portion of the thorax, mostly on the right. Not infrequently we have heard such peculiar complaints as those of "bulging out" of the lower part of thorax and "coming up to the heart."

Out of 29 cases, there were 17 with complaints of constipation, often of some days' duration. Finally, there were complaints of shortness of breath when walking rapidly or working steadily.

In the roentgenoscopy of our patients, under the right dome of the diaphragm the layer of air of various size had been observed, which compelled us to examine these patients more in detail. At the beginning of our study we noted that the layer of air in the case of interposition is more distinctly seen when the patient turns to the oblique position (to the right nipple). Later on, the method of investigation of the right hepatodiaphragmatic region of the patient became obligatory in roentgenoscopy of the thorax. This method permits the diagnosis of interposition in the cases where a rather small amount of gas in the large intestine is present at the time

of examination. In order to be certain that it was really a section of the large intestine, we filled the latter with a contrast enema. In a series of cases we also inflated the large intestine with air. When we did this during roentgenoscopy with the patient in the vertical position, we could observe that the layer of air between the anterolateral wall of the abdomen and the liver increased as the intestine was filled by gas; as the intestine was inflated the liver was displaced downward and toward the median line, making, as it were, a turn around its horizontal axis. The filling of the intestine by the contrast mixture and its inflation by air in the cases of interposition showed that the principal part in the anomaly was played by hepatic flexure which extends from the lateral part to the upper surface of the liver, being thus placed directly under the right dome of the diaphragm.

In order to answer the question as to which variant of the position of the colon occurs most frequently among the patients having interposition, we adopted Dr. Kuprianof's classification which distinguishes four types of position of that section of the large intestine in man.

The first type is a horseshoe form, with its convexity turned upwards, the second a horizontal one, the third a V-shaped one with three bends: hepatic flexure, splenic flexure, and between them the transverse colon, and the last type, the oblique position of the colon where the right bend is blunt. Among our cases the third type was the most frequent, that is a V-shaped form of the position of the colon with sharply pronounced hepatic bend.

In the cases of pronounced and moderate inflations of the large intestine by gas in the patients with interpositions, we were unable by percussion to find the posterolateral borderline of the dullness of the liver owing to its displacement downward and toward the median line by the distended intestine. Anteriorly, the lower border of the liver usually protruded from under the edge of the rib, probably owing to the general prolapse and rotation of the liver. In the external examination of our patients we did not note any deformities of the thorax.

Out of 21 patients examined repeatedly by us the permanent form of interposition was found in 14, while the temporary occurred in 7 cases. In the latter group the liver was seen at its usual place in cases of repeated roentgenoscopy. Inflation of the intestine by air showed that the distended large intestine was situated below the liver. As to the form of the gaseous bubble in our cases we can note the following. In some cases the gaseous layer occupies the whole space under the dome of the diaphragm, while in others, independently of the degree of inflation at a given moment, it occupies only a partially lateral area. The constancy of form of the gaseous bubble had been noted in our patients at multiple repeated roentgenoscopies. The attempt at further inflation of the intestine resulted only in the enlargement of the gaseous layer under the dome of the diaphragm, and in the cases in which the bubble occupied only the lateral portion of the subdiaphragmatic space, we were unable to obtain the complete dislodging of the liver. The former of the above described types of interposition of the large intestine may be called a complete one, while the latter type where only partial separation of the liver from the dome of the diaphragm exists may be called a partial one (see Figs. 1, 2 and 3). In the partial type the adhesions between liver and diaphragm are likely to have a certain importance among the rest of the cases, as was found in Case XII, in which at autopsy the adhesions between liver and diaphragm and pancreas were present because of the presence of gastric ulcer. In another of our cases (Case VIII) where at roentgenoscopy a complete form of interposition was observed, at autopsy there was found an elongation of the colon (60 cm.) without any contact between the diaphragm and liver.

Case XXIX represents quite a different picture: here at repeated roentgenoscopies

and on the roentgenogram we had seen displacement of the liver which was distended by the large intestine downward and laterally. The gaseous interlayer with distinct haustra fills the whole space under the right dome of the diaphragm and immediately passes to its left dome. On the roentgenogram (Fig. 4) we can distinctly see the lower border of the heart, the whole of diaphragm, lower thoracic vertebrae and, at the lower right costal edge, the shadow of liver above which and directly under the dome of the diaphragm the large intestine is seen distended by gas. The contrast mixture given through the mouth showed the normal passage of food and natural arrangement of both esophagus and stomach. The latter is of an atonic form with the lower border 2 cm. lower than the iliac crests. The filling, by the enema, of the large intestine by the contrast medium confirmed the opinion that the section of the intestine distended by gas under the domes of the diaphragm belonged to the large intestine. The presence of peritonitis is considered one of the causes of such an unusual form of interposition.

Out of 29 cases, a complete form of interposition occurred in 14 cases, while in 18 there was a partial form. When comparing both the groups as to their roentgenoscopic data we can state that the partial form of interposition occurs more often in gastrointestinal diseases and in older persons (above forty years).

Is there any definite connection between the formation of interposition of the large intestine in our patients and infectious diseases from which they had suffered?

The histories of our cases give no positive answer to this question. In studying them, it is impossible to state that any single disease had regularly been repeated in each. The causal connection may be seen only between the interposition and some organic alterations of the gastrointestinal tract. Of these, as other writers also note (Podkaminsky, and others), first of all tumors of the stomach and ulcers of the duodenum should be mentioned. In the autopsy of 2 cases (VIII and XII) we have a corroboration of our surmises. In Case XII there was an ulcer of the lesser curvature of the stomach and coalescence between stomach, liver and pancreas. Undoubtedly, these adhesions assisted in the displacement of the liver downwards and created conditions favorable to the passing of the large intestine under the dome of the diaphragm. In Case VIII the formation of the interposition was likely to be due to two narrowings, each 2 cm. long, 6 cm. apart, in the region of the colon which produced an impediment in the region of the hepatic flexure of the large intestine. At autopsy of the same patient were found pleural adhesions more pronounced to the right which probably weakened the suction power of the lungs, and the liver was displaced downward, creating conditions favorable for the passing of the distended intestine between the liver and dome of the diaphragm.

Turning to the question of the effect of physical labor on the formation of interposition, it should be noted that the majority of our patients were doing manual labor (21 out of 29). In a number of histories severe labor since childhood was noted (as in Cases VII, X, etc.). In the histories of 10 cases there is clear indication of the connection of their complaints with some trauma (contusion) of the right half of the chest, abdomen or back; in several cases the contusions were so heavy that the patients had stayed in the hospital for a more or less prolonged time. It seems to us that in such cases, trauma was the favorable moment for the interposition.

In noting, in the vast majority of our cases, some morbid phenomena or other as accompanying the interposition of the large intestine we ought to state, however, that in some single cases the evidence of interposition did not cause any particular discomfort. There was one case that was discovered by us when examining workers and officials *en masse;* this patient had no particular complaint.

There was some additional value in find-

ing out, on roentgenoscopy of patients, the evidence of interposition of the large intestine. I mean to say that in a number of cases we had been able to establish a causal relation between this phenomenon and that complex of morbid phenomena, which in our usual clinical practice could not be satisfactorily interpreted. For instance, persistent constipation, which could not be cured by means of medicaments, may be attributed to the interposition.

This is well illustrated by Case IX in which a complete and permanent form of the interposition was noted: the patient had had an independent stool only two times during a month and a half stay at the hospital.

It is clear that when examining a patient in the clinic the possibility of interposition of the large intestine must always be kept in mind, for not infrequently the interposition is far from being a harmless anomaly, and in many cases it can bring about distressing disorders.

On the basis of the analysis of the above-described cases and data available in the literature, the following conclusions can be drawn:

(1) The evidence of hepatodiaphragmatic interposition of the large intestine can, at present, be discovered only by roentgen examination. It has been observed rather often.

(2) The first oblique position (at the right nipple) is the most suitable for showing some minor forms of interposition, because in this position the gaseous layer between the liver and diaphragm is more distinctly seen. In the obscure cases the filling of the intestine by contrast medium is suggested.

(3) The following may be noted as the causative factors in interposition of the large intestine:

(a) alteration of intra-abdominal pressure;

(b) diseases of the gastrointestinal tract, such as gastric tumors and ulcers, ulcers of the duodenum, complicated by adhesions between the liver, stomach and pancreas;

(c) defects of the supportive apparatus of liver and atrophy of liver;

(d) alteration of the statics and dynamics of the diaphragm associated with disease conditions of the organs in the chest.

(4) The interposition of the large intestine is more often observed in older persons (thirty to fifty) and in those doing manual labor. Women suffer from interposition less frequently than men.

Trauma is likely to have some influence on the origin of this anomaly of the position of the large intestine.

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Vol. 39, No. 6

ROENTGENOLOGIC ASPECTS OF SPINA BIFIDA OCCULTA

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FROM a study of the literature on this subject, it is evident that this condition is important, not for the reason that abnormalities of the bone are demonstrable, but more for the reason that such bony malformations are uniformly combined with intraspinal pathologic changes which are much more profound in their effects than those which may be attributed to the bony defects. In the analysis of the available reports on this anomaly, one is impressed with the regularity of occurrence of such changes, and with the possibilities of producing clinical syndromes referable to nerve disturbances. The intraspinal changes which were consistently found to be associated with spina bifida occulta consisted of masses of soft tissue,—fat, fibrous tissue and muscle,—deposited around the nerve roots so as to produce compression of the nerves; and cords of fibrous tissue, extending between the bony portions of the spine and the nervous elements, producing traction on the nerves. Such a combination of abnormalities was thought to be responsible for several clinical pictures, the most important of which were deformities of the feet, enuresis and trophic ulcers of the lower extremities.[2] In cases studied at autopsy, it was obvious that the anatomical disarrangements were so formidable that attempts at surgical correction were hopeless. Whatever attempts have been made to eliminate the pathologic features by surgical measures have resulted in varying degrees of success in improving clinical conditions.

Spina bifida occulta at the present time enjoys the status of a roentgenologic curiosity. The anatomic or roentgenographic conception is that of an incomplete fusion of one or more laminae in the midline, and application of the term seems to be limited to this conception. It may be mentioned incidentally as a finding, but as such is usually dismissed as an insignificant feature which has no relation to any clinical condition.

Such an attitude may be justifiable when it is considered that this very type of anomaly (cleft) is found in only a small percentage of cases of any disease in which spina bifida occulta has been held responsible; when it is considered that this form of spina bifida occulta is frequently found incidentally in cases in which no clinical features are attributable to it; and when it is considered further, that in children this is thought to be a normal finding which disappears at later ages. Thus, with all these considerations, the idea has arisen and become perpetuated in the minds of medical observers that spina bifida occulta has no significance whatever in its relation to clinical phenomena.

It is my purpose to show that spina bifida occulta is very probably related to a variety of clinical pictures; that application of this term should not be limited to the presence of an incomplete fusion or cleft of the neural arches as apparently it is, but rather that it comprises a large group of defects which in their morphological and developmental characteristics are identical with spinal clefts and are therefore true cases of spina bifida occulta. This has been determined from the anatomical study of material from 33 patients who were subjected to operation for various diseases considered to be due to spina bifida occulta. Whatever observations are presented here include only those which involve the lumbosacral region.

ROENTGENOGRAPHIC FINDINGS

It is generally recognized that no reliable diagnosis of spina bifida occulta can be made in young children. The time at which it is possible to be certain of such defects varies somewhat, but it seems that these

FIG. 1. Roentgenogram of patient, female, aged fifteen, with muscular rheumatism of lower extremities and pes equinus on one side. Laminal cleft of first sacral vertebra. Immediate result (five weeks after operation) was improvement of muscle condition and also of deformity.

abnormalities can be recognized at the age of six years. As stated, the standard type of malformation which is spoken of as spina bifida occulta is the laminal cleft or incomplete fusion of the laminae in the midline. It is also quite generally recognized that the lumbosacral region is the most common site at which such defects are located. From reports of others, there is apparently little difference in the incidence of location between the fifth lumbar vertebra and first sacral vertebra.

On the basis of observations which I have made, it is evident that the fifth lumbar vertebra is very rarely the seat of spina bifida occulta; that malformation occurs most frequently in the upper sacral region, particularly the first and second sacral segments; that in this location it may assume the form of an incomplete fusion of the posterior neural arch (Figs. 1 and 6), though this is by no means the most common type of defect which is recognized as spina bifida occulta. Most often it is possible to find that the laminae of the first sacral segment are fused in the midline; that, below that level, and involving the laminae of the first or second sacral vertebrae or both, small defects are visible (Figs. 2, 3 and 4). These vary in size from 2 to 3 mm. to 10 or 12 mm.; they are round, oval or irregular in shape, and they are sharply or dimly outlined against the background of the bodies of the sacral verte-

FIG. 2. Case of low back pain in a man aged thirty-four. Radiation on right side to gluteal region, thigh and leg. Roentgenogram shows small oblong defect, immediately to the right of the midline, and involving the lower part of a rudimentary spinous process of the first sacral lamina. A similar defect, though smaller, is seen in the lamina of the third sacral segment. Operation resulted in complete relief of symptoms.

brae. They are usually situated more conspicuously on either side of the midline and are frequently multiple. It might thus be said that the anomalies which are here designated as spina bifida occulta are sharply delineated with regard to location but show a wide range of variation with respect to size, shape and number. In general, it is safe to state that the term spina bifida occulta is applicable to any congenital defect of the laminae of the upper sacral vertebrae.

INTRASPINAL PATHOLOGIC CHANGES ASSOCIATED WITH SPINA BIFIDA OCCULTA

In combination with the bony malformations, it is in practically all cases possible to demonstrate certain features within the spinal canal which are undoubtedly instrumental in disturbing the function of the sacral nerves. These consist of (1) masses of fat tissue, in contact with the nerve roots of the cauda equina and (2) bands of fibrous tissue, extending between the ventral surface of the laminae and either the dura or the nerve roots.

Fig. 3. Case of muscular rheumatism in a boy aged twenty. Disabled for five years. Roentgenogram shows, in lower part of first sacral vertebra, a small round defect, situated in the midline. Operation resulted in marked improvement.

Fig. 4. Case of hematogenous osteomyelitis of both femora (upper third of shaft). Roentgenogram shows defect of bone between laminae of first and second sacral vertebrae on each side. In addition, a defect is seen in the upper half of the first sacral segment, immediately to the left of the midline. Operation, five months ago, was followed by closure of discharging sinuses on each side. Subsequently an abscess formed in the femur on the right side, resulting again in a draining sinus.

The deposits of fat tissue are usually found at the level of the first, second and third sacral segments. They are in close contact with the dural sac laterally and

sometimes dorsally; distal to the dural sac they envelop the nerve roots of the cauda. These tissues are soft and friable in consistency, yellow or brownish yellow in color, and never firmly adherent to the structures with which they are in contact (Fig. 5).

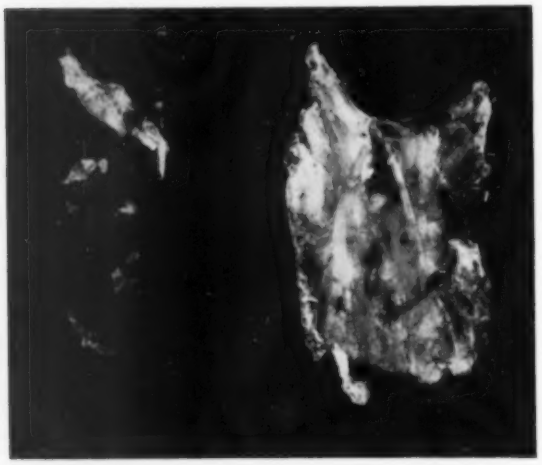

FIG. 5. Photograph of specimen removed from patient represented by Figure 3. The large specimen shows the ventral aspect of the laminae. The specimen of bone was broken during the operation and the rounded margin at the top represents the level of the upper portion of the defect. From the edge of the upper border near the midline, a slender band of fibrous tissue is seen, directed diagonally downward. The small pieces of tissue near the bone specimen are pieces of fat and fibrous tissue which were removed from the canal. The bone specimen was 3 cm. long and 2 cm. wide.

On microscopic examination these tissues are seen to consist of adult fat, divided into lobules by fibrous tissue septa. Many specimens show the presence of new fibrous tissue and evidence of old hemorrhage. A few show indications of inflammation. More unusual findings are calcified areas and the presence of striated muscle among the fat tissue.

The cords of fibrous tissue between the ventral aspect of the laminae and the contents of the canal vary in number and in size. Many of the smaller strands are broken in the course of the operation. The heavier cords which attain a thickness of 2 or 3 mm. are attached to the bony canal near the midline. They are usually under tension. At their other ends they can sometimes be traced to the dural sac or the fat tissue masses lateral or distal to the dura. On microscopic examination, these are seen to consist of dense fibrous tissue with small amounts of fat tissue.

It is easy to understand that such an abnormal arrangement of tissue may bring about an impairment of function of the nerves which are involved. From experiences in this series, it is evident that such alterations are not only very common, but that they are found in a large variety of clinical pictures in which they have not been suspected. Concerning the relationship between the pathologic findings and the roentgenographic appearance, it may be said that whenever the bony defects are demonstrable in the roentgenogram, it is practically certain that the intraspinal changes are also present. In some of the cases in this series it has been necessary to rely on clinical data only, as the patients were too young to show any dependable roentgenologic evidence of malformation.

SPINAL FLUID FINDINGS

Examination of the spinal fluid previous to examination has not been considered necessary. At operation, which consists of a laminectomy of the upper two or three sacral vertebrae and removal of the pathologic structures about the nerves, it is easy to obtain fluid, as the dural sac is exposed.* In 29 specimens, obtained in this manner, it was noted that there was no abnormality of the color; that none of the specimens showed the presence of globulin or any abnormality of the sugar content; that, however, the cell count was abnormal in all cases. This varied from 15 cells per cubic millimeter to 1,450 cells per cubic millimeter. The differential cell count of the fluid showed a predominance of small lymphocytes (70 to 100 per cent).

* Since submitting this paper, the procedure of obtaining spinal fluid in this manner has been discontinued, for the reason that it is considered potentially dangerous.

CLINICAL FINDINGS IN SPINA BIFIDA OCCULTA

In analyzing here the clinical manifestations encountered in this series, it is intended principally to call attention to the relationships which are thought to exist between the pathologic features and the clinical phenomena. The relationship between the roentgenologic and the anatomic features has already been stated. In considering the mechanism by which the various disease processes are brought about, it is obvious that these must result directly or indirectly from the effects of disturbances produced by interference with the function of the affected nerves. The arrangement of the anatomic features within the spinal canal, as they are seen at operation, leaves no doubt that they are capable of producing a dysfunction. With the exception of one case, the findings at operation were typical in every instance.

It is realized that the time of observation has been too short and the number of cases too small to enable one to form any conclusive opinion on end results.

Muscular Rheumatism. This is a symptom-complex, consisting of pain and tenderness of voluntary muscles. It has been fully described by Port[3] and whatever statements are made here regarding it may be found in his monograph. Pain is most severe during activity, though it may be noticeable while the patient is at rest. Tenderness may be elicited at various points in the muscle substance or the tendon, and as a rule is much more widely distributed than the symptoms would indicate. As a result of the pain during activity, the muscle is frequently held in a state of partial contraction, in order to avoid any pain caused by overstretching. Depending on the muscles which are affected, various types of deformity may result. While the feet are most often affected, symptoms may present themselves in the gluteal muscles. In most cases of this kind, it is possible to elicit tenderness in the upper sacral region in the midline and likewise usually lateral to the midline. This feature has led to the study of the roentgenographic appearance of the sacrum, and by such examination it was found possible to detect a number of different forms of defect in the sacrum. These defects were invariably present though they manifested whatever variations could be seen in the size, shape and number. In 10 patients on whom operation was performed, it was possible to see typical pathologic findings in all of them. Complete relief of symptoms is obtainable in the majority of cases and varying degrees of improvement in the remainder. Improvement is most apparent within the first few weeks after operation.

Low Back Pain. This disability, which is the subject of extensive discussion, is, as a rule, divided roughly into two classes, —the type of pain in which there is radiation to the thighs, legs and feet, and that which is confined to the region of the lower spine without radiation. In the former, the term "low back pain with sciatica" is frequently used when referring to the distribution of the radiating pain. Recently, Badgley[1] has pointed out certain inadequacies of the term "sciatica" and suggested the term "postaxial plexalgia" as a more accurate designation in describing the true nature of the pain.

In the examination of patients with this disability, it is possible to elicit tenderness in certain areas in the lower spine. These are usually mentioned as the lumbosacral and the sacroiliac regions. In attempting to locate accurately the points of tenderness, it is found that these are situated in the muscles or tendons; that they are most conspicuous in the upper part of the sacrum, the sacroiliac and the gluteal regions, the tensor fasciae latae, the muscles of the leg and frequently the short plantar muscles. In their distribution, these findings are therefore very similar to those of muscular rheumatism. The roentgenographic examination of the sacrum reveals quite accurately the appearance characteristic of spina bifida occulta.

In this series, there were 7 patients who had low back pain with radiation. At

operation, the characteristic anatomic changes were present in the sacral canal in all cases but one. Complete cure was obtained in 3, marked relief from the pain in 3, and 1 was a failure. In 2 cases of pain without radiation, both were cured by operation.

Spastic Paralysis. In a small series of cases it was possible to detect roentgenographic changes in the sacrum, which were characteristic of spina bifida occulta. In 5 cases laminectomy of the sacrum revealed typical abnormalities in the sacral canal. Operation was followed by certain unmistakable signs of improvement in the patients, though not sufficient to indicate any close connection between the pathologic and the clinical findings.

Infantile Paralysis. In this condition, also, it was found that spina bifida occulta was demonstrable regularly in the roentgenogram. Largely on the basis of these findings, operation was performed in 2 cases. This consisted of a laminectomy of the sacrum and removal of the abnormal structures in the sacral canal. There was a noticeable improvement in each case. However, it is obvious that further study is necessary for an accurate appraisal of the merits of this form of treatment. From the consistence with which spina bifida occulta is found roentgenographically and the discovery of typical pathologic alterations in the spinal canal, though limited to a study of 2 cases, there is reason to believe that these features are essential factors in the development of infantile paralysis. However, it is obvious that these would constitute only a part of the pathologic picture.

Osteomyelitis. Attention was drawn to the possibility of spina bifida occulta as a factor in this disease by the incidental observation of such defects. Accordingly, a further study was made of the sacrum in cases of osteomyelitis. It was noted that this abnormality occurred as a constant finding. There was reason to suspect a connection between spina bifida occulta and osteomyelitis, and operation was undertaken in 3 cases. In deciding on this course of treatment, it seemed reasonable to assume that the structures in which such foci of infection had their origin and in which they persisted in spite of treatment, were composed of tissues which were subnormal in vitality; that this inferiority was due to neurotrophic dysfunction, and that such disturbance of function was traceable to the pathologic structures in the spinal canal. In the 3 cases mentioned, as well as in one case which followed a compound fracture, the roentgenographic and the operative findings were typical. The immediate results of operation are satisfactory. Discharging sinuses heal rapidly and in the course of months the roentgenographic appearance of the affected bones shows a return to a more normal state. Information regarding end results is not yet available.

Visceral Dysfunction.

(*a*) *Enuresis.* This is one of the conditions for which many attempts have been made at correction by removing the abnormal formations within the spinal canal. Reports by others indicate a measure of success in overcoming the nervous imbalance which is considered to be the basis of this inability to control the flow of urine. In my series there was one case of nocturnal enuresis associated with Legg-Perthes' disease. Following operation, which consisted of a laminectomy, the enuresis was apparently cured for several weeks, though after that time there was a recurrence of the former trouble. In 3 patients who complained of urgency and frequency of urination during the day time, this condition was also relieved immediately after operation. In one case there was a recurrence, in another a definite improvement was maintained for six months and in the third the result is not known. The impression is gained that, although the innervation of the bladder and the function of urination are dependent in part on the sacral parasympathetic nerves, this type of treatment is uncertain in cases of enuresis.

(*b*) *Menstrual dysfunction.* This was noted in the histories of 4 patients, and consisted of pain during the menstrual periods. Operation, consisting of a laminectomy of the sacrum and removal of the pathologic structures in the canal, was undertaken for other ailments. In one case, the pain was relieved completely and relief continued for six months. In another case it was partly relieved. In the third case, pain was eliminated, but the menstrual periods, which previous to operation were regular at twenty-eight days, now appeared every fourteen days. In the fourth case, there was also an increase in the number of periods, occurring every ten days, instead of the usual twenty-eight days. In addition, it was as painful as it was before operation.

(*c*) *Constipation.* Approximately one-half of the patients in this series stated that they were habitually constipated, so that the use of cathartics was necessarily daily or several times a week. In some this had existed for years or perhaps during their whole life. In a number of these patients, roentgenographic studies of the barium meal were undertaken. These studies showed two features in the majority of cases,—a filling defect in the descending colon and at times the sigmoid, indicative of a spasm of those portions of the bowel, and a delay in the passage of the meal (Fig. 6). The examinations were not continued beyond a period of forty-eight hours, but during that time there was very little progress of the meal along the colon. This condition was interpreted as a colospasm, resulting in a partial obstruction of the colon at that level. The roentgenographic peculiarities were noted not only in those patients who complained of constipation but also in those who had regular evacuations.

Following operation, which was in all cases performed for the relief of other diseases, there was in practically all instances a prompt relief of the constipation. The patients no longer required cathartics and the stools were normal in appearance and consistency. Such relief is evidently permanent as several patients have been observed for more than a year without recurrence. It is probable that the restoration of this function is the result of the removal of irritating factors in the spinal canal, where the effect is undoubtedly one of stimulation of the sacral parasympathetic nerves, by the abnormal formations seen in spina bifida occulta.

Fig. 6. Roentgenogram showing barium meal twenty hours after it was taken by mouth. Case of muscular rheumatism in a girl, aged ten, with a marked pes equinus and flexion contracture of the knee on one side. Characteristic filling defect of the descending colon and sigmoid. This patient had six lumbar vertebrae. In the last lumbar the laminae are not fused. In the first sacral segment a defect is seen in the laminae and involving both sides of the midline though for the most part on the left side. Three weeks after operation, there was complete correction of the deformities of the foot and the knee.

DISCUSSION

From a survey of the cases which form the basis of this report, it is evident that there are certain clinical syndromes which

are associated with characteristic roentgenologic features of the sacrum. The latter are, when present, indicative of the presence of accompanying pathologic structures within the spinal canal. This combination of the roentgenologic and the anatomic malformations has been verified many times at operation, so that it may be considered safe to use the roentgenologic diagnosis as a sure indication of the presence of harmful influences affecting the sacral nerves. However, in order to have a complete understanding of spina bifida occulta, it is necessary to revise the present conception of this anomaly to include a large group of defects in the sacrum which have heretofore been overlooked.

In emphasizing thus the importance of both the roentgenographic and the anatomic aspects of this abnormality, it is not to be inferred that these are in all cases directly connected with the clinical conditions in which they are found. This is evident from the results of treatment, which consists in the removal of the pathologic formations about the nerves. There is reason to believe that the changes found in the sacral canal constitute only a part of the complete pathologic picture.

SUMMARY

This analysis is based on the study of thirty-three cases of spina bifida occulta. From the roentgenologic study of the sacrum, it was noted that this structure is the seat of many different forms of defect, which, on the basis of their anatomic and developmental characteristics, must be classed as true cases of spina bifida occulta. The importance of these malformations lies in their association with abnormal tissue deposits within the sacral canal, so arranged that they may interfere with the normal function of the spinal nerves. The actual presence of such tissues about the nerves has been determined by operation. They consist largely of fat tissue, with varying amounts of fibrous tissue. They are in contact with, and often completely envelop, the nerves of the cauda equina. Whatever nerve disturbances become evident are produced mechanically by pressure or constriction.

Among the clinical conditions, which have been found to be combined with such abnormalities, are muscular rheumatism, low back pain, spastic paralysis, infantile paralysis and hematogenous osteomyelitis. The results of treatment by surgical removal of these harmful influences, are variable, though, in some of the clinical pictures, sufficiently striking to justify further application of this form of therapy.

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Vol. 39, No. 6

TRAUMATIC AXIAL ROTATION BY GEAR MOVEMENT OF THE CARPAL SCAPHOID AND TRAPEZIUM WITH SUBLUXATION AND FORESHORTENING OF THE FIRST METACARPAL*

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WE ARE reporting an unusual case of wrist injury with subluxation of the first metacarpal bone and rotation of the trapezium and scaphoid in opposing direction by gear movements.

REPORT OF CASE

R. C. (No. H.6582), a girl, aged sixteen, fell on the sidewalk several weeks before her admission to the outpatient department. She landed on her outstretched left hand. There was slight pain at first but no swelling. She was able to use her hand for every purpose. The mother had noticed that the hand was turning to one side. Recently, she complained of some pain at the base of the thumb.

FIG. 1. *A*, foreshortening of the first metacarpal with abduction position of 45° of the thumb. The thumb is held slightly flexed at its basal phalanx. The right hand is normal and is shown for comparison. *B*, profile view of left hand showing the prominence of the base of the first metacarpal.

FIG. 2. *A*, limitation of opposition of left thumb is shown. *B*, limitation of adduction in the frontal plane of left thumb is shown.

The left hand is radially abducted at the wrist, producing a marked prominence of the ulnar styloid. The first metacarpal is abducted at an angle of 45°. Because of a volar and proximal displacement of the base of the first metacarpal, there is an apparent shortening of the thumb. A peculiar emptiness or depression is

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present in the snuff-box as though the scaphoid were missing. Measurements from the snuff-box to the distal end of the first metacarpal on the left side are 1½ inches; on the right side, 2¼ inches. Adduction of the thumb to the index finger in the plane of the hand is incomplete. Passive abduction of the first metacarpal places it in a more palmar position. Frontal adduction of the thumb is not possible because of bony impingement at the base of the metacarpal. In the normal right hand, frontal adduction is free, to the middle finger. Opposition of the left thumb is also limited by bony impingement. This motion, however, is possible to a limited degree, so that the thumb parallels the index finger. On the right hand, opposition is possible to a degree where the thumb parallels the ring finger. By flexion of the joints of the thumb, she can appose the left thumb to the little finger. In a profile view, with the thumb extended and abducted as much as possible, the displacement of the first metacarpal bone is well seen. There is some limitation of backward extension of the first metacarpal as compared with the normal side. In the relaxed position, with the metacarpal abducted at 45°, there is a dropping of the thumb at the basal joint. This is due to overaction of the flexor brevis pollicis. The abductor pollicis longus is seen to be radially displaced. The extensor pollicis longus is strong and is capable of extending the thumb. The extensor pollicis brevis cannot be felt. Passive motion of the metacarpal produces pain at its base, and tenderness is also present at this site.

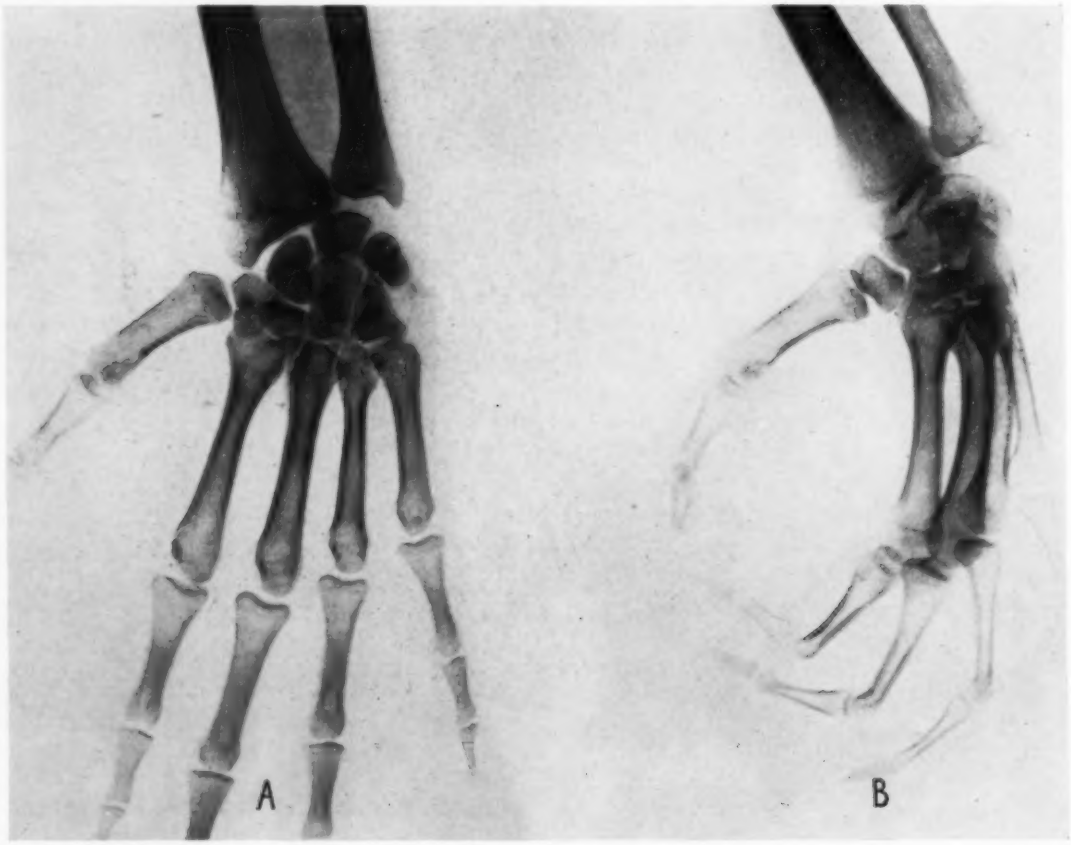

FIG. 3. *A*, shows upward and outward subluxation of the base of the first metacarpal. The distance between the radial styloid and the first metacarpal base is diminished. Note the clockwise rotation of the trapezium and the counterclockwise rotation of the scaphoid, both of which have been rotated in their perpendicular axes. There is apparent shift of the entire carpus to the ulnar side. *B*, shows foreshortening of the scaphoid with lesser prominence of the scaphoid tuberosity.

The roentgenograms show an outward subluxation of the first metacarpal on the trapezium. The latter bone is rotated in a clock-

wise direction so that its scaphoid face is more ulnar. As a result of this, the first metacarpal approaches the radius more closely than normally. The scaphoid is rotated in a counterclockwise direction ulnarly 90°, so that its tuberosity is placed distally and in the same vertical line with the proximal part of the bone. The longitudinal axis of the rotated scaphoid is now in line with the second metacarpal. This line forms an angle of 160° with the radius. The radial part of the scaphoid is now placed between the os magnum and the trapezium, directly proximal to the trapezoid. The scaphoid is foreshortened in this direction. In the oblique view, the scaphoid is also definitely foreshortened, although it is still slightly longer than wide. It appears to be more horizontally placed. The ulnar end of the bone is wider than the radial or tuberosity end. The tuberosity is seen but is distinctly less prominent than normally. In this oblique view, there is less evidence of subluxation of the first metacarpal. There is also a more ulnar position of the semilunar bone. In the lateral view, the foreshortening of the first metacarpal is more evident. The position of the greater multangular is altered so that it is no longer oblong but oval and is superimposed on the base of the first metacarpal. The scaphoid is clearly outlined. It is more horizontal than oblique and its tuberosity less prominent. The anteroposterior and oblique views show the radial shifting of the whole hand with an apparent ulnar shifting of the whole carpus.

Fig. 4. Shows rotation of the trapezium so that it is superimposed on the base of the first metacarpal. Its shadow is more oval than oblong. The scaphoid is placed more transversely than normally.

In order to determine the mechanics involved in rotation of the carpal scaphoid, a cadaver study was done. The scaphoid was freed of its ligaments and the various possible directions of rotation of the bone then observed. The direction of rotation of the scaphoid was determined by viewing it from the dorsal aspect of the wrist. It was possible to rotate the scaphoid on any of its three axes. The longitudinal axis of the scaphoid is similar to the transverse axis and corresponds to the longitudinal plane of the bone. The vertical axis of the scaphoid corresponds to a line that is perpendicular to the transverse axis and is also parallel to the bones of the forearm. The perpendicular axis corresponds to a line that runs posteroanterior and is perpendicular to both the transverse and vertical axes. Because of the abutment of the scaphoid tuberosity against the radius, as well as the oblique direction between the scaphoid and semilunar, clockwise rotation of the scaphoid in the left wrist was impossible. Furthermore, the ulnar part of the bone is wider than the radial part. Hence, it would be easier for the radial part to be rotated since it would demand less room. Counterclockwise rotation of the scaphoid in the left wrist was possible in various planes, but clinically, it would seem to be possible only in the horizontal plane of the carpus. In Figure 5*A*, the scaphoid was rotated 90° in a counterclockwise direction on its verti-

cal axis in the line of the forearm. The tubercle is now dorsal and overlies the body of the scaphoid instead of being radial. In Figure 5*B*, the scaphoid was rotated 90° both in its vertical and transverse axes in that order, so that the concavity of the scaphoid is dorsal instead of volar and the tubercle is dorsal instead of radial. In the case reported above, the scaphoid was rotated 90° in a counterclockwise direction on its perpendicular axis, so that its proximal surface became more radial and the tubercle became distal instead of radial. It is evident then, that in the left wrist, the scaphoid can be rotated only in a counterclockwise direction. In the right wrist, scaphoid rotation is possible only in a clockwise direction.

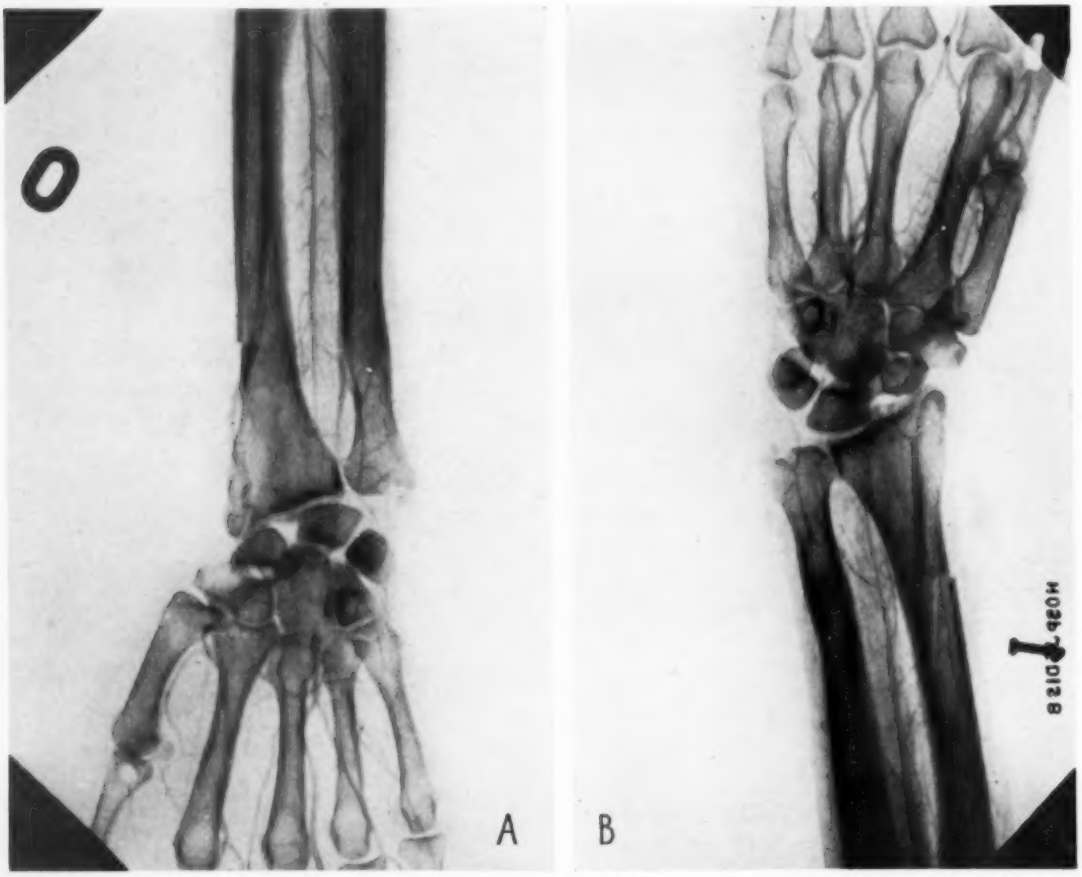

FIG. 5. Cadaver study. *A*, the scaphoid was rotated 90° in a counterclockwise direction on its vertical axis. The tubercle is now dorsal and overlies the body of the scaphoid. *B*, the scaphoid was rotated 90° both in its vertical and transverse axes so that the concavity of the scaphoid is dorsal instead of volar and the tubercle is dorsal instead of radial.

The simplest type of dislocation of the carpal scaphoid is probably a translatory shift of the bone radially. An isolated radial dislocation of the scaphoid was reported by Buzby[2] in which the bone was placed at the tip of the radial styloid. Speed[4] stated that an isolated dislocation is rare because of the strong attachment of the tuberosity. It may occur, however, in a mechanism similar to that of the lunate dislocation when the hand is forced into hyperextension (or flexion), while in radial deviation. Trauma which tears the strong radial collateral ligament will allow rotation of the scaphoid as seen in this case. The mechanics operating in this case, however, is much more complex than that present in an isolated rotation of the scaphoid. The impact of the fall in this case forced the first metacarpal to sublux-

ate proximally. The direction of the force upon the metacarpal was in abduction, extension and cephalad. Due to this force, the carpometacarpal ligaments ruptured, allowing the base of the first metacarpal to subluxate proximally on the trapezium. During the process of subluxation, however, the abutment of the metacarpal base on the trapezium caused the latter bone to rotate in a clockwise direction. Because of the anatomical relation of the trapezium with the tuberosity of the scaphoid, any rotation of the trapezium will tend also to rotate the scaphoid, but in an opposing direction. This is due to the abutment of the trapezium on the radial surface of the scaphoid tuberosity. The resultant opposing rotational directions of these bones can be likened to the opposing movements found in a gear. The force which tore the carpometacarpal ligaments subluxated the metacarpal and rotated the trapezium, was thus transmitted to the scaphoid and rotated it also. Before rotation could take place, however, so that the scaphoid tuberosity became displaced distally, the strong radial collateral ligament had to give way. In a somewhat similar case reported by Leuret,[3] he described a tear of the trapeziometacarpal ligament only. He made no mention of the radial collateral ligament. When the scaphoid rotates so that its tuberosity becomes distally placed, either the radial collateral ligament must give way, or else that portion of the radial styloid process to which it attaches must be avulsed.

In any injury, in which the force applied to the first metacarpal takes the direction such as noted in this case, various degrees of damage may result. The simplest abnormality will be a Bennett fracture. Where the force applied is not too great, as in the cases of Baumann and Mouchet,[1] the trapeziometacarpal ligament may be torn, allowing subluxation of the base of the metacarpal. With greater force, rotation of the trapezium and scaphoid may occur, as in our case. With still greater force, the lower end of the radius may be fractured, as reported in one of Leuret's two cases.

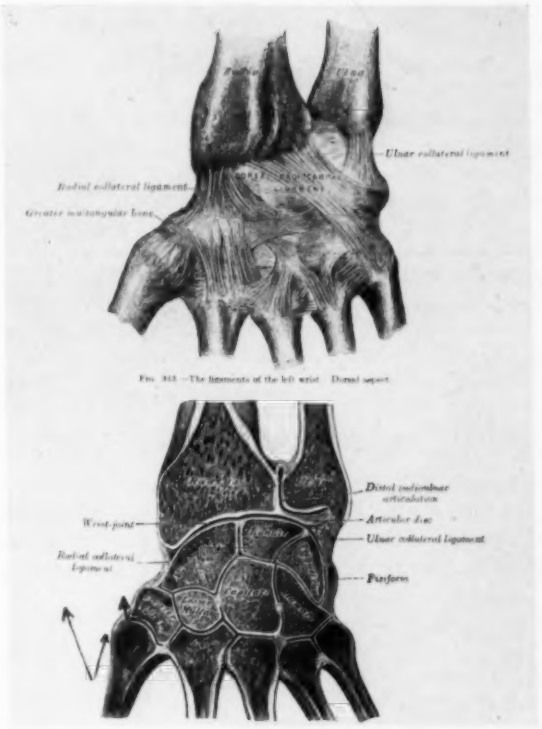

Fig. 6. Shows anatomical relation of the first metacarpal, trapezium, and scaphoid, with its ligamentous attachments. It also shows direction of force applied to the first metacarpal and transmitted to the trapezium and scaphoid, producing opposing gear movements, as described in the text. (From Gray's Anatomy, 1924, p. 329.)

It may be possible that early cases can be reduced by manipulation. Leuret reports reduction by manipulation, although he showed no post-reduction roentgenogram. Late cases may need open operation. Our patient received no treatment since she could not be followed.

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Twenty-third Annual Meeting: Clift Hotel, San Francisco, Calif., June 13–14, 1938.

EDITORIAL

BOECK'S SARCOID

BOECK'S sarcoid, or sarcoidosis, is a disease which has been variously designated as lupus pernio, sarcoid, benignes miliar lupoid, benign lymphogranulomatosis, ostitis tuberculosa multiplex cystoides, maladie de Besnier-Boeck, and Hutchinson-Boeck's disease. Longcope and Pierson[1] tell us that our information about the disease has accumulated in a most disjointed manner, for it has been referred to quite separately as a disease of the skin, as an affection of the bones and as a disease of the lymph nodes. It is only within comparatively recent years that these various clinical manifestations have been recognized as different expressions of a single disease process.

The clinical description of the disease goes back to the time of Jonathan Hutchinson who observed a patient with the cutaneous lesions of sarcoid, together with a brawny edematous swelling of the forefinger. This was in 1869, and he later described a case, with some illustrations, in 1875. From time to time various reports of isolated cases have appeared, and quite recently Longcope and Pierson have reviewed the entire literature, calling particular attention to the various clinical manifestations of the disease process.

The disease known primarily as Boeck's sarcoid is characterized by the formation of nodules in the cutaneous and subcutaneous tissues, and the skin over these areas has a somewhat telangiectatic appearance. The distribution of the lesions and the histological pictures are somewhat distinctive. The disease is of particular interest to the roentgenologist primarily because of the somewhat characteristic lesions which occur in the bones. The first report of these lesions was by Kienböck who gave a description of the roentgenological changes which were observed in the bones of the hands and feet (though he was ignorant of their relation to sarcoid of the skin, and included his patients in a series of cases of syphilis of the bones). It is to Kreibich (1904) that we owe the first report of involvement of bone in cases of sarcoid lesions where the changes were definitely associated with lupus pernio, and somewhat later Jüngling described the bone changes to which he gave the name of ostitis tuberculosa multiplex cystica. These changes observed by Jüngling were in all respects similar to those reported by Kienböck and by Kreibich. Most of the changes which Jüngling described were confined to the phalanges of the hands and feet, but in some of the cases the distal ends of the bones of the forearm were involved. Various observers in this country have reported cases exhibiting typical bone changes, notably Finnerud, Goeckerman, and Doub and Menagh.[2]

Boeck's sarcoid is a disease of early adult life, at least most of the cases that have been reported have been in the early adult age group. The progress of the disease is somewhat insidious. Though it may have a fairly acute onset it later lapses into a chronic state. Most of the early changes and the most obvious ones are those in the skin and lymph nodes with involvement of the bones of the hands and feet. The bone structural changes are first evident as thickening of the trabecular architecture in the end of one of the phalanges of a finger where small punched-out areas later appear, and there is a somewhat peculiar

[1] Longcope, W. T., and Pierson, J. W. Boeck's sarcoid (sarcoidosis). *Bull. Johns Hopkins Hosp.*, April, 1937, *60*, 223–296.

[2] Doub, H. P., and Menagh, F. R. Bone lesions in sarcoid: roentgen and clinical study. Am. J. Roentgenol. & Rad. Therapy, 1929, *21*, 149–155.

combination of destruction and repair of bone. The clear cystic-like areas vary in size and number. At times a whole phalanx may be affected. Not infrequently the disease process becomes arrested and the fingers may return to practically normal state, but more often a considerable amount of mutilation results. Curiously enough, there is no generalized atrophy of the bone of the affected hand and but little localized atrophy of the diseased bone. There is no sequestration in the diseased part and there is no accompanying periostitis. The neighboring joints are not involved. The shaft of the affected bone may show slight enlargement but the cortex itself is rarely broken. Occasionally there may be no external evidence of disease, but usually the fingers are somewhat irregularly enlarged with blunting of the tips of the fingers and tendency to dorsal flexion of the last phalanx.

The appearance of the roentgenogram is fairly characteristic. Fleischner and Doub and Menagh described two types of roentgen manifestations: in one type the primary lesions appeared to be mainly an alteration of the trabecular structure of the bones which shows a coarser architecture than the normal. As the lesions progress areas of destruction appear in the bones. These areas of destruction may be either central or cortical or both, and vary in size from a millimeter or more in diameter to complete destruction of the bone. In the other type, the lesions begin as punched-out areas of bone destruction in the phalanges, and these areas of bone destruction may extend entirely through the bone and there is occasionally a line of eburnation around the margin. Doub and Menagh suggest that it is entirely probable that these two types are different manifestations of the same process and have the same end-results.

The process has to be differentiated from tuberculous dactylitis or spina ventosa, osteitis fibrosa cystica, syphilitic disease of bone, particularly the congenital type; confusion of the disease process with a malignant process is not likely because of the multiplicity of the lesions themselves, the rarity of metastatic processes attacking the phalanges, and also by the fact that the cortex is not broken through.

Another feature of the disease process which is not so well known is the changes that occur in the lungs. Kirklin and Morton[3] and more recently Longcope and Pierson have called attention to these pulmonary changes and particularly to their roentgenological manifestations. The lung changes that are seen typically in these cases of patients suffering from Boeck's sarcoid consist of bilateral fairly diffuse linear infiltrations of the middle of the lower half of the lungs extending from the hilum well out toward the periphery. These infiltrations may be so dense as to obscure the borders of the heart shadow. Superimposed on this are many discrete opaque areas, ranging in size from miliary nodules to areas perhaps 1 cm. in diameter. Singularly enough the apices are not affected in most cases and signs of pleurisy or fluid are usually absent. Occasionally shadows such as are produced by enlarged lymph nodes are observed in the superior mediastinal region. These mediastinal lymph nodes may occur without changes in the lungs. Longcope and Pierson state that the clinical features attending the pulmonary disease in these patients are quite remarkable, there being frequently no symptoms or physical signs that would indicate the presence of an extensive disease of the lungs, and it is the rule that there is little or no elevation of temperature, though occasionally cough and expectoration do occur. The condition has to be distinguished from other chronic conditions of the lung. It does not differ in many respects from the changes observed in old fibrous tuberculosis, but the non-involvement of the apices often is a clue to the probable diagnosis. It also has to be differentiated from pneu-

[3] Kirklin, B. R., and Morton, S. A. Roentgenologic changes in sarcoid and related lesions. *Radiology*, 1931, *16*, 328–333.

[4] Eichenlaub, F. J., and Sandler, I. L. Boeck's sarcoid. AM. J. ROENTGENOL. & RAD. THERAPY, April, 1938, *39*, 596–600.

moconiosis but here too the nodules are more definite and more numerous and the linear markings and striations may not be so pronounced. Kirklin and Morton have called attention to the fact that sarcoid lesions in the lung do not have a tendency to form cavities and are more diffuse than the usual type of bronchiectasis, though a differential diagnosis between the two conditions is sometimes difficult.

The disease usually pursues a chronic and often a somewhat benign course, though spontaneous healing of the lesions may occur with complete disappearance of the lesions in the lungs as well as those in the bones. As a rule, however, the disease is a chronic one with relapses. It is a disease which is not very amenable to treatment.

From an analysis of their cases, Longcope and Pierson conclude that the disease pursues the course of a chronic, generalized infection which produces few constitutional symptoms but causes rather remarkable pathological changes in many structures of the body, and they emphasize the importance of a study of the chest in these cases where so frequently there is involvement at the roots of the lungs or mediastinum and the lesion produces somewhat characteristic shadows in the roentgenogram.

The etiology of Boeck's sarcoid remains unknown. Many observers consider the disease a peculiar form of tuberculosis, though most of the investigators who have set out to prove this point have failed. The protean manifestations of the disease, its peculiar affinity for the terminal phalanges of both the hands and feet as well as its skin manifestions and the somewhat characteristic lung changes would warrant a more widespread knowledge of its clinical and roentgenographic manifestations.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. C. B. Peirce, University Hospital. Ann Arbor, Mich. Annual Meeting: Atlantic City, N. J., Sept. 20–23, 1938.

AMERICAN COLLEGE OF RADIOLOGY
Secretary, Dr. E. L. Jenkinson, 1439 S. Michigan Ave., Chicago, Ill. Annual meeting, 1938: To be announced.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: San Francisco, Calif., June 13–17, 1938.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Pittsburgh, Pa., Nov. 27–Dec. 2, 1938.

RADIOLOGICAL SECTION, BALTIMORE CITY MEDICAL SOCIETY
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RADIOLOGICAL SECTION, CONNECTICUT MEDICAL SOCIETY
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets twice annually in May and September. Special meetings may be called by the Chairman.

RADIOLOGICAL SECTION, LOS ANGELES CO. MED. SOC.
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ILLINOIS RADIOLOGICAL SOCIETY
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RADIOLOGICAL SOCIETY OF NEW JERSEY
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NEW YORK ROENTGEN SOCIETY
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NORTH CAROLINA ROENTGEN RAY SOCIETY
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cisco. Meets monthly on first Monday at 7:45 P.M., alternately at Toland Hall and Lane Hall.

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University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. V. W. Archer, University Hospital, University, Va. Meets annually in October.

Cuba

Sociedad Cubana de Radiologia y Fisioterapia
Secretary, Dr. Francisco Padron, Enrique, Villuendas 64, Havana, Cuba. Meets monthly in Havana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets on the third Thursday of each month, from November to June inclusive, at 8:15 P.M., at 32 Welbeck St., London, W. 1, or as advertised.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine, 1, Wimpole St., London, W. 1.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to Nov. incl. for scientific discussion.

Canadian Association of Radiologists
Secretary, Dr. A. C. Singleton, Medical Arts Bldg., Toronto, 5, Ontario.

Section on Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext., Halifax, N.S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

Continental Europe

Belgian Society of Roentgenology
Secretary, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

Sociedad Española de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7, Madrid, Spain. Meets monthly in Madrid.

Société de Radiologie Médicale de France
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel.
Meets annually in different cities.

Société Francaise d'Electrothérapie et de Radiologie Médicale
Meets monthly on fourth Tuesday, except during month of August and September, 12 Rue de Seine, Paris.

Association of German Roentgenologists and Radiologists in Czecho-Slovakia
Secretary, Dr. Walter Altschul, German University, Prague, II.52.

Deutsche Röntgen-Gesellschaft (Gesellschaft für Röntgenkunde und Strahlenforschung)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent Secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

Süd- und Westdeutsche Röntgengesellschaft
Meets annually in different cities.

Nord- und Ostdeutsche Röntgengesellschaft
Meets annually in different cities.

Dutch Society of Electrology and Roentgenology
Holds two meetings a year in Amsterdam, one in the Spring, and one in the fall.

Societa Italiana Radiologia Medica
Secretary, M. Ponzio, University of Turin, Prof. Turin.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania.
Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson, Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8 o'clock, the place of meeting being selected by the Society.

Polish Society of Radiology
Secretary, Dr. Jan Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime:

Society of Medical Radiology in Sweden
Meets in Stockholm.

Society of Medical Radiology in Norway
Meets in Oslo.

Society of Medical Radiology in Denmark
Secretary, Dr. G. Biering, Copenhagen.
Meets on the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

Society of Medical Radiology in Finland
Meets in Helsingfors.

Vienna Roentgen Society
Meets first Wednesday of each month, at 6:30 P.M. at Zentral-Röntgen Institut des allgemeinen Krankenhauses Alserstrasse 4.

Orient

Japan X-Ray Association
c/o Orthopedic Surgery, Tokyo Imperial University. Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto Japan. Meets bi-monthly on third Sunday.

DEPARTMENT OF TECHNIQUE

Department Editor: ROBERT B. TAFT, M.D., M.S., 105 Rutledge Ave., Charleston, S. C.

A SIMPLE AND INEXPENSIVE TOMOGRAPHIC METHOD*

By GILBERT H. ALEXANDER, M.D.
BROOKLYN, NEW YORK

DURING the last few years there has been an increased interest in the representation of body sections roentgenographically, described variously as planigraphy, stratigraphy, tomography, and laminagraphy.

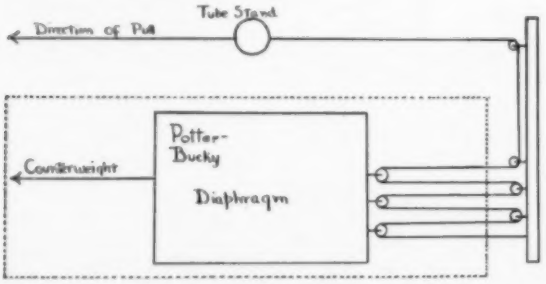

FIG. 1. As the tube stand is pulled in the direction of the arrow, the Potter-Bucky diaphragm is drawn in the opposite direction through the system of pulleys. In this case the ratio of motion is six to one and the resultant section will be at one-seventh the target-film distance above the film (dotted lines represent table top).

Various methods have been described and apparatus devised by Bocage,[2] Kieffer,[6] Bartelink,[1] Vallebona,[5] Ziedses des Plantes,[7] and Grossmann.[3] In all methods, the principle utilized is that the source of radiation and the recording surface be moved in such a manner that the projection of one plane remains constant in relation to the recording surface; all other planes show a continuous variation and are blurred. *Any method is valid if it meets the requirements that as the focal point of the tube moves in any direction, the film moves in a direction opposite to that of the tube, the degree of motion of the film being at a fixed ratio with that of the tube, the plane of the film remaining parallel with its previous positions as it moves.*

The purpose of this paper is to describe a method which can be adapted to the standard Potter-Bucky table simply and inexpensively. The standard Potter-Bucky table with rail mounted tube stand allows horizontal motion of the tube and horizontal motion of the film in the Potter-

FIG. 2. Section through the chest at a level 5 cm. from the posterior chest wall. The cavity noted was partially obscured in the ordinary film.

* From the Department of Roentgenology, Kings County Hospital, Brooklyn, New York, Richard A. Rendich, Director.

Bucky mechanism. With this motion, the geometric problem is one of similar triangles, and the requirements to be met are that as the tube is moved in one direction, the Potter-Bucky diaphragm must be moved in the opposite direction at a fixed ratio with the movement of the tube. I chose a pulley system to obtain this motion because it is simple, inexpensive, and requires no exacting mechanical workmanship.*

Fig. 3. Section 5 cm. from posterior chest wall.

The connections are made as in Figure 1. The tube stand is pulled manually during the exposure and the Potter-Bucky mechanism is moved simultaneously in the opposite direction by means of the pulley system. The ratio, as illustrated, is six to one and will give a section at a level one-seventh the target-film distance above the film. This ratio, however, is arbitrary and may be changed by varying the number of pulleys.

* Twining[4] has described an adaptation of the Potter-Bucky table for tomographic study. He obtains the desired motion by means of a lever system.

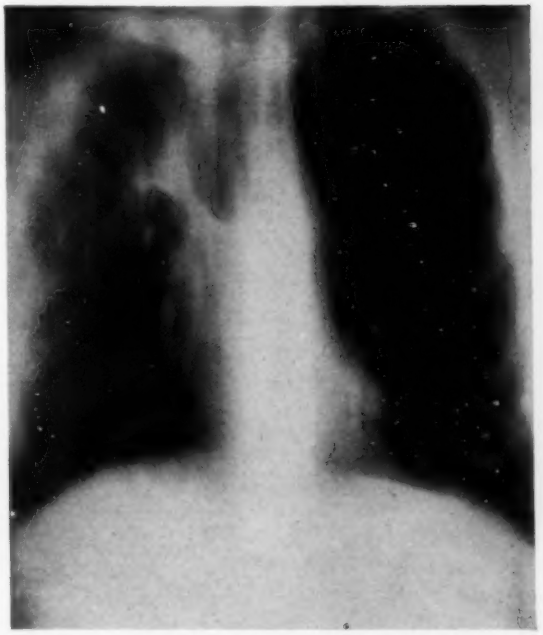

Fig. 4. Same case as Figure 3, section 12.5 cm. from posterior chest wall. Note herniation of mediastinum which was not demonstrated on ordinary film.

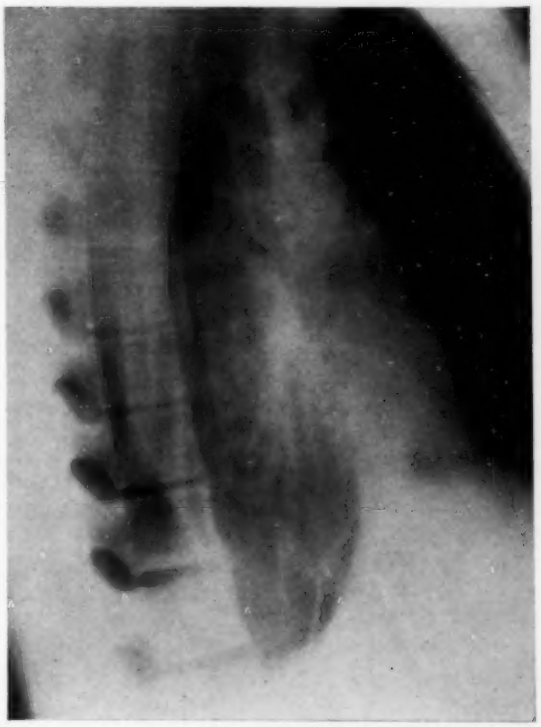

Fig. 5. Section through the thoracic spine. Patient was in the lateral position. Note absence of rib shadows.

Any desired plane of section may be obtained by varying the target-film distance or by varying the pulley ratio. In practice we have found it desirable to vary both.

The level of the desired plane may be obtained by the use of a simple arithmetic calculation as follows:

Distance of plane of section from table top equals $\frac{\text{target-film distance}}{\text{No. of pulley strings plus one}}$ minus distance from film to table top.

The thickness of the section may be controlled by varying the degree of motion or by the use of wedge-shaped cones.

The pattern of blurring of shadows not at the level of section is similar to that of Grossmann's tomograph.

The resolution of detail is dependent on the ratio of motion, the size of the focal spot, and the rigidity of the mechanism. With other factors fixed, the resolution of detail is independent of the target-film distance. To minimize error, we use a string with as little stretch as possible and attach a counterweight to the other end of the Potter-Bucky diaphragm. With an effective focal spot of 2 mm. and a pulley ratio of seven to one, we have been able to resolve coarse bony detail.

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Vol. 39, No. 6

THE CONSTRUCTION OF AN INEXPENSIVE ROENTGEN KYMOGRAPH

By CLYDE McNEILL, M.D.
LOUISVILLE, KENTUCKY

IN 1934 when we constructed the roentgen kymograph described in this article, commercial apparatus was not available in this country. An excellent machine is now offered for sale by an American manufacturer, but it is felt that some roentgenologists may wish to construct their own apparatus. The total cost of the material used in the kymograph described in this article was about $30.00.

There is no claim to originality in this article. All of the important principles of the kymograph have been worked out by others. We have incorporated in our kymograph the best features of the apparatus built by S. E. Johnson, Pleikart Stumpf, I. S. Hirsch, and others.

The numbers in the illustrations refer to the following parts of the apparatus.

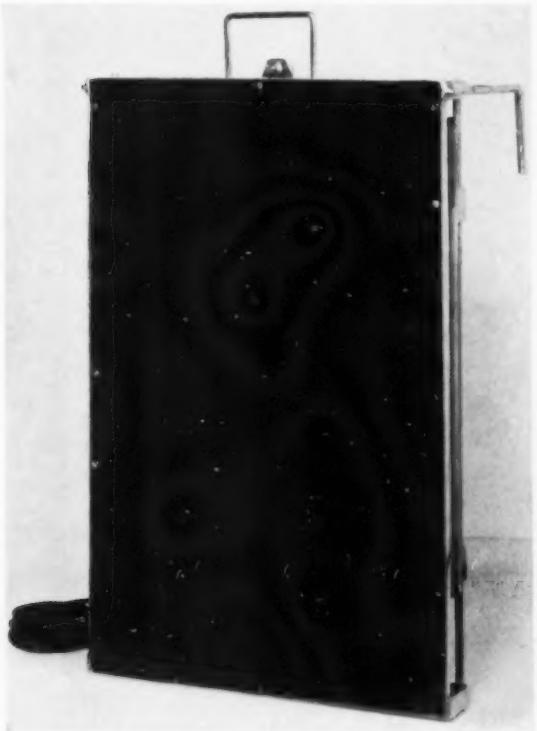

FIG. 1. Front of kymograph.

1. Handle for lifting cassette carrier.
2. Plunger type release. When the cord is pulled the plunger is withdrawn, releasing the cassette carrier.
3. Vertical rods along which the cassette carrier travels. These are $\frac{3}{8}$″ stainless steel rods 24″ long.

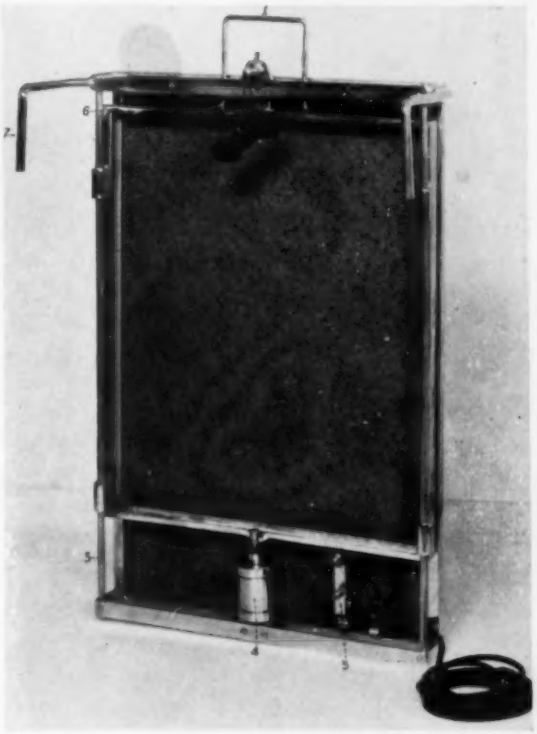

FIG. 2. Back of kymograph.

4. Dash pot, cut down from metric valve used on a toilet to control the flow of water. This dash pot consists of a bronze cylinder and a piston with a needle valve to control the flow of oil.
4a. Cap which fits over needle valve. This needle valve can be turned with a screw driver, thereby accelerating or slowing the movement of the cassette carrier, which is attached to the piston.
4b. Spring around piston, which is compressed when the cassette carrier is lifted.

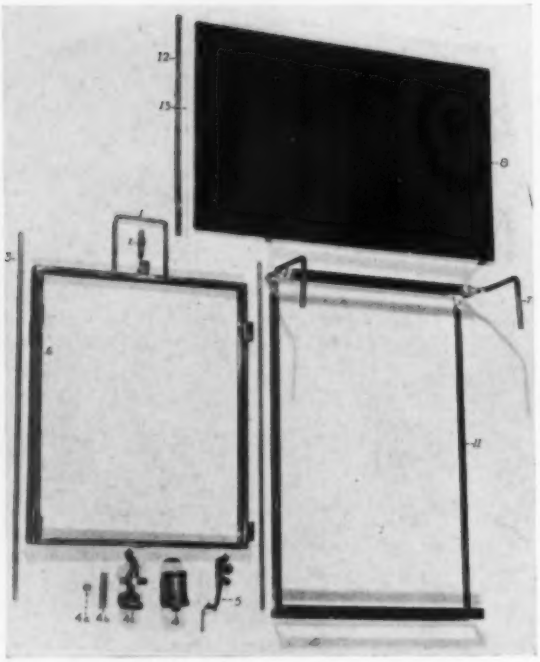

Fig. 3. Photograph of parts used in construction of kymograph.

4c. Piston of dash pot with leather washer and needle valve.

5. Electric switch which automatically starts and stops the exposure at the proper time. This switch consists of only two pieces of spring brass insulated by fiber. The lower part is attached to the pressdwood back of the machine and projects outward so as to make contact with the upper piece when it moves downward. The projecting portion of the lower piece of brass is 12.0 mm. long. The upper portion is attached to the cassette carrier, and as it moves downward makes contact over a distance of 12.0 mm. Wires from the two pieces of brass are plugged into the control cabinet so that the high tension roentgen-ray switch will be closed while the two pieces of brass are in contact.

6. Frame of cassette carrier made of No. 14 gauge black iron. This carrier is grooved to take a 14″×17″ cassette, which slips into it from the right side.

7. Handles for hanging the apparatus on vertical plate changer.

8. Bakelite over front of apparatus 15″×24″.

9. Grid.

10. Pressdwood back of grid, 15″×24″.

11. Frame of apparatus. The sides are $\frac{1}{2}$″×$\frac{1}{16}$″ angle iron. The ends are $\frac{3}{4}$″×$\frac{1}{8}$″ cold rolled flat iron.

12. Lead strips for grid $\frac{1}{16}$″ thick and $14\frac{7}{8}$″ long and exactly 12.0 mm. wide. These are sawed with a fine tooth band saw, and the edges are buffed off until smooth.

13. Paper spacer for grid. This paper must be 0.4 mm. thick, and is cut $\frac{1}{16}$″×$14\frac{7}{8}$″. These are placed between the strips of lead to insure accurate spacing of 0.4 mm.

All of the joints of the frame are welded. On the cassette carrier are welded four tubes to fit over the vertical rods to provide friction bearings. These bearings must be oiled frequently. These tubes are $1\frac{1}{4}$″ long and consist of $\frac{1}{4}$″ pipe through which a $\frac{3}{8}$″ drill has been run.

The most important part of this apparatus is the grid, and this must be constructed with extreme care. The lead strips and the

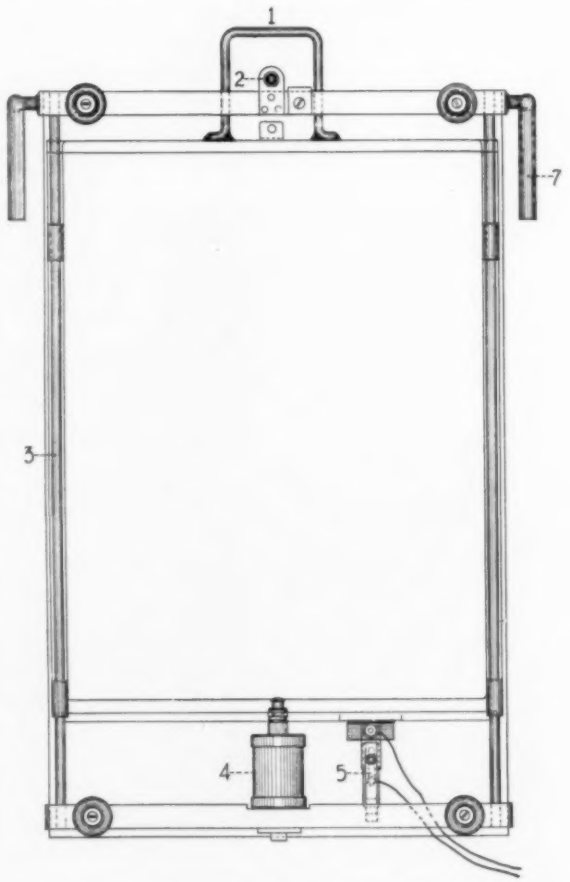

Fig. 4. Drawing of back of kymograph.

spacing may be of any desired dimensions. Narrow strips will permit one to record more points on the heart surface, and wide strips will give longer records of each point. Most workers have found that a satisfactory compromise consists of lead strips 12.0 mm. wide and 0.4 mm. apart. If desired, several grids can be constructed and substituted at will.

The lead strips, with the paper spacers between, are laid out on a pressdwood board on which hot animal glue has been placed. Not more than a half dozen strips are glued at a time. The lead strips and paper spacers are brought into firm contact by light taps from a wooden hammer. When a space $14\frac{7}{8}$" wide and 20" long has been covered, glue is spread over the lead strips and the bakelite front is placed over the grid, and held firmly in place for some time by clamps. When the glue is dry a

Fig. 6. Roentgenogram of grid.

14"×17" film is made of the grid to determine whether the spacing is even. If there are fragments of lead in the slits, or if the edges of the lead strips are not smooth, vertical lines will be formed in the kymogram.

The entire apparatus is put together to see that all of the parts fit, and is then taken down so that the metal parts can be chromium plated. In most towns there are plating establishments that will do this at a reasonable price. However, this part of the cost can be eliminated by painting the metal parts. If one is willing to spend more money, the apparatus can be improved in several details. Ball bearings may be substituted for the friction bearings of the cassette carrier. This is especially desirable if many films are to be made in the horizontal position. The dash pot can be replaced by a Potter-Bucky mechanism for moving the grid. The Potter-Bucky mechanism is more constant in action, especially in the horizontal position, and the speed can be controlled more easily. The switch can be replaced by a more expensive type with

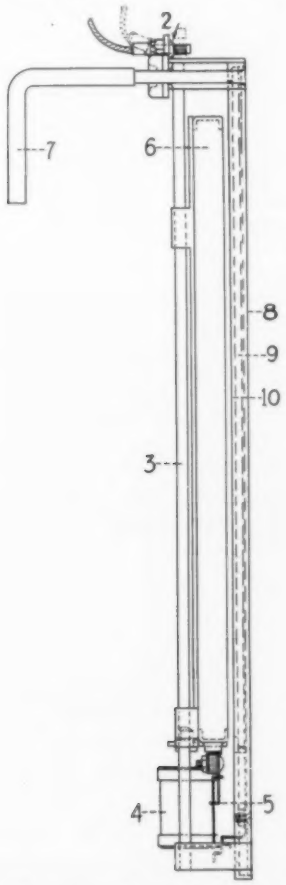

Fig. 5. Drawing of kymograph, side view.

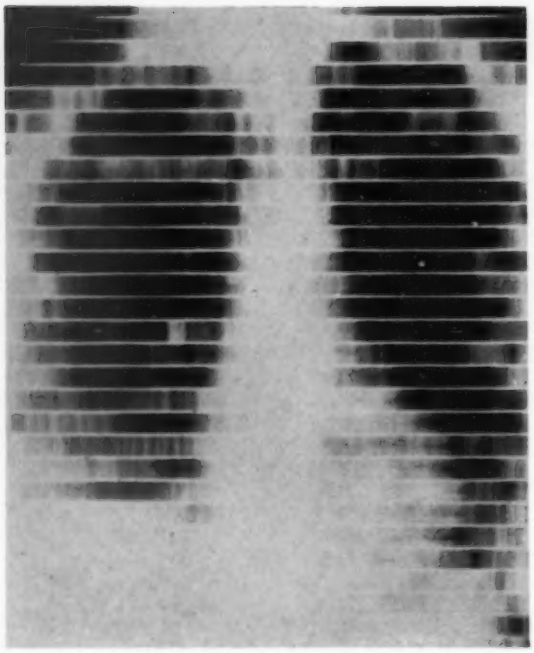

FIG. 7. Roentgen kymogram of chest, upright position. Film moves downward.

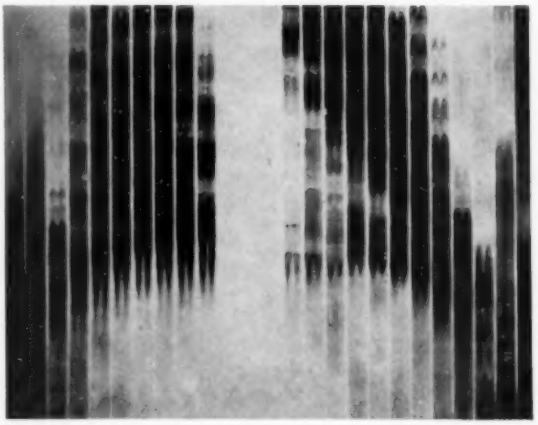

FIG. 8. Roentgen kymogram of diaphragm, prone position.

silver contacts, which is tripped at a certain point by the movement of the grid, thereby opening and closing the circuit more abruptly. However, the apparatus exactly as described above has given excellent service for more than three years.

the switch may need to be changed several times before the duration of the exposure will correspond with the passage of film over one lead strip. Once the switch is correctly adjusted the time will be independent of the film speed, and exposures of any desired length may be made by simply tightening or loosening the screw under the cap (*4a*). The exposure should be long enough to cover one entire cardiac cycle. Usually one second will suffice. Because of the narrow slits in the grid, the voltage may be raised as high as desired without

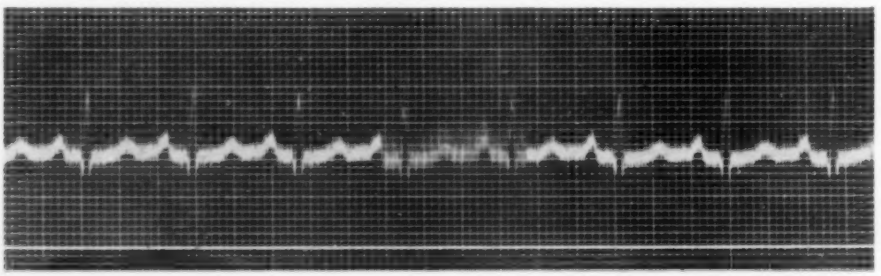

FIG. 9. Synchronization of electrocardiogram with the kymogram illustrated in Figure 7. Exposure registers as a rapid oscillation of galvanometer string (120 per second). Exposure starts at peak of P-wave or beginning of auricular systole.

The cassette carrier must move smoothly and without any jerky movement, or there will be transverse lines in the kymogram. The film should move for a short distance before the exposure starts, so that it will be running at a uniform rate. The length of the projecting portion of the lower part of

producing fog from secondary radiation. If a target-film distance of 6 feet is used, the cardiac silhouette can be traced in either systole or diastole.

The kymograph can be synchronized with the electrocardiograph without any special apparatus. The electrocardiograph

must be one of the newer models with an interference eliminator. The kymograph, the plate changer to which it is attached, and the stool upon which the patient sits must be carefully grounded. The electrodes are applied in the usual manner for one of the conventional leads. After the electrocardiograph has run for a second or two the roentgen exposure is made. The induction produced during the roentgen exposure will be recorded in the electrocardiogram, and will indicate the exact points in the cardiac cycle at which the roentgen exposure began and ended (Fig. 9).

I am especially indebted to Mr. J. W. Fowler, engineer at the Norton Memorial Infirmary, for technical assistance in building this apparatus.

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OBSERVATIONS ON LATERAL VIEWS OF HIPS

By EDWIN N. CLEAVES, M.D., F.A.C.R.
BOSTON, MASSACHUSETTS

DURING the past few years, there has been an increasing demand from surgeons and orthopedists for lateral views of the hips. Various methods have been devised, some of which have been useful, some of practically no value. At times it is better to employ one method, and at times, another. Most methods give a rather distorted view, and very few procedures employ the Potter-Bucky diaphragm. For these reasons we have thought it worth while to call attention to a technique, not very well known, perhaps, but very useful at times.

FIG. 1. Showing the position for obtaining the lateral view.

This method is not a new one. It was mentioned by the late Dr. Gaenslen.[1,2] He employed it, in part, in connection with fractures of the neck of the femur. We have had little experience in such cases, but we have used the method under other conditions.

The method is quite simple, obtaining (1) an anteroposterior view; (2) a lateral view. The roentgenograms are all taken using a Potter-Bucky diaphragm.

(1) We take either a single roentgenogram or stereoscopic roentgenograms of the pelvis, showing both hips. This is the usual anteroposterior view, the patient lying on his back, with the toes together, pointing directly upward.

(2) The patient then flexes the knees and hips, bringing the feet up as near the buttocks as possible, keeping the feet together. The knees are then spread apart, as far to the side as the lame hip will permit, the normal hip being abducted to a comparable distance. The roentgen tube is placed so that the central ray is directed

[1] Gaenslen, F. J. Fracture of neck of femur. *J. Am. M. Ass.* 1936, *107*, 105–114.

[2] Gaenslen, F. J. Subcutaneous spike fixation of fresh fractures of neck of femur. *J. Bone & Joint Surg.*, 1935, *17*, 739–748.

FIG. 2. Normal boy, twelve years of age. *A*, anteroposterior view; *B*, lateral view.

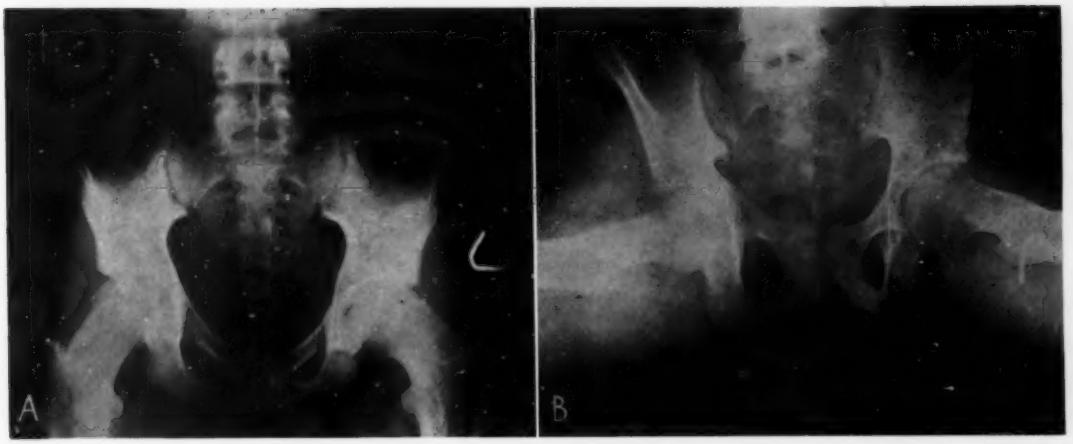

Fig. 3. Slipped epiphysis. *A*, anteroposterior view; *B*, lateral view.

Fig. 4. Old congenital hip. *A*, anteroposterior view; *B*, lateral view.

Fig. 5. Malum coxae senilis. *A*, anteroposterior view; *B*, lateral view.

parallel with the long axes of the femoral shafts, centering on the symphysis pubis. This position gives a lateral view of both hips (Fig. 1). The accompanying figures show a series of cases illustrating results obtained by using this technique (Figs. 2–8).

FIG. 6. Brodie's abscess. *A*, anteroposterior view; *B*, lateral view.

FIG. 7. Deposit in bursa in relation to the tendon of the gluteus medius. *A*, anteroposterior view; *B*, lateral view.

FIG. 8. Fracture of neck of femur. *A*, anteroposterior view; *B*, lateral view.

Vol. 39, No. 6

SUGGESTIONS FOR SIMPLIFYING TECHNIQUE IN DIAGNOSTIC ROENTGENOLOGY

By W. C. HUYLER, M.D.
NEW YORK CITY

FOR some years my work has included interpretation of roentgenograms sent in to us from laboratories all over the country. Many of these are not good and some are even very poor. We find films spoiled by over- or under-penetration, by distortion from too short a tube-film distance, by motion of one sort or another, by fog so heavy that it destroys the contrast, by poor positioning, by loss of detail from using too large a focal spot, and by improper processing resulting in dirty, fogged, marked films. And occasionally good films come to us cracked and marred by fingernails after being tightly rolled for mailing. Such films fail to bring out pathology that is present and may contain artefacts that cause confusion or even simulate disease conditions. The defects in these films are not unavoidable accidents; they are due to insufficient study of the actual technique of the work, and as they can be corrected by attention to details, some thoughts along the line of improvement and simplifying of technique may be helpful.

Perhaps it will be worth while to review some of the elementary principles which govern roentgen technique and so get clearly in mind the basis for the following suggestions. In this connection it is best to start with the question of motion as it affects time of exposure, since in living subjects motion of one sort or another must always be considered. In roentgenologic work, as in photography, a certain rate of motion calls for a certain speed of exposure to "stop" it. The optimum exposure time, then, is one that is just short enough to avoid distortion from motion, not shorter, since other factors demand as long an exposure time as practical. At the heart border, tissue speeds reach 20 mm. per second or more, while at the lung periphery rate of tissue motion is 5 mm. per second or less. The movements of the intestines are relatively slow, and in roentgenography of the extremities there is, within the ability of the patient to remain quiet, no appreciable motion. In roentgenography of the chest the optimum exposure is around 1/30 sec., so the shortest exposure of which the available apparatus is capable, up to 1/30 sec., should be used. In gastrointestinal roentgenography, where rate of motion is much slower, exposures of 1/2 sec. have been found satisfactory. In areas where there is no involuntary motion, time of exposure is limited only by the ability of the patient to remain quiet or hold his breath.

Variation in time and proportional variation in milliamperes have exactly the same effect. Both vary the amount of roentgen ray. Therefore, as long as the product of the two, the milliampere-seconds, is unchanged, the milliamperage and the time can be relatively varied at will to suit tube requirements or other conditions. When there is no motion, a film made at 250 ma. and 1/10 sec. will be identical with a film made at 25 ma. and 1 sec., other factors remaining unchanged. It is more practical to think in terms of milliampere-seconds than of milliamperes and of seconds as separate factors. Milliampere-seconds represents the amount of roentgen rays. High milliamperage with corresponding lowering of kilovoltage (peak) improves contrast by reducing fog from secondary radiation, so that technique should always be laid out with a view to using, within practical limits, high milliamperage and low kilovoltage (peak).

It has seemed to us that the effect on definition of the focal spot size is often not fully appreciated. It is worth while to take a roentgenogram of a bone with a 3 mm. or larger focal spot and then repeat it with a 1 5 mm. spot, all other factors being iden-

tical. The improvement in definition with the smaller focal spot is ample return for the expense of another tube and the trouble of changing tubes. The manufacturer's rating charts must be carefully followed, and the focal spot must not be overloaded, but the smallest possible focal spot should always be used. Factors of technique should be chosen with this in mind, as proper selection of the factors will often make feasible the use of a smaller focal spot. Line focus tubes are practically universal now and the improvement over the old round focus is sufficient to justify the added expense. Rotating anode tubes are a long step in the same direction but are at present quite costly.

Longer tube-film distance would have the same effect as a smaller focal spot if the focal spot could remain the same size as it is moved away from the film; but roentgen rays follow the law of light rays in that the amount of roentgen radiation on a given surface area varies inversely as the square of the distance from the source—in this case the tube-film distance. With double the tube-film distance, four times the milliampere-seconds are needed, the kilovoltage (peak) remaining the same, and so a larger focal spot is necessary. It happens that the necessary increase in focal spot size just about balances out the effect of the greater distance, and there is no improvement in definition. There is, however, with longer tube-film distance, less distortion from divergence of rays, and a more nearly accurate picture of the size and shape of the object is obtained. Where exact size and shape are important, as in the chest, longer tube-film distances are needed. In practice 2 meters is found to be adequate, and the further gain beyond this is not sufficient to make up for the additional power needed.

It is best to think of kilovoltage only as the factor that determines penetration, and so it is the factor to be varied to meet different conditions of thickness and radiodensity. It is the one variable factor in the system of charts to be described below.

Many of the poor films that we see are spoiled by loss of contrast and detail due to fog. Fog may be caused by stray radiation, ordinary white light exposure, dirty solutions, excessive lag in screens, old films, or exposure to air during development, but the most important fog is that due to secondary rays. When roentgen rays pass through an object, secondary rays are given off in all directions. Those secondary rays which continue along the path of the primary rays actually assist in making the picture, but the others which spread out at all angles and strike the film from all angles produce a smooth gray fog over the film, greatly impairing contrast. High kilovoltage (peak), long exposure time, and thickness of the object increase secondary rays and hence fog. The value of low peak kilovoltage (with increased milliamperage) and of short exposure time (by the use of screens, etc.) is obvious. Cones, by limiting the primary rays to the field under examination, eliminate the secondary rays that would otherwise be set up outside this field and radiate back onto the film. Cones should be used wherever possible. They should not be round, but should conform to the shape of the film. The Potter-Bucky diaphragm, by stopping rays that are proceeding toward the film along paths other than the course of the primary rays, is the best aid in eliminating secondary ray fog and is well worth its cost. As a general rule, with object thicknesses up to 10–12 cm., none of these precautions against fog, except cones, is needed. Beyond this thickness, screens are advisable with ordinary film, and for greater than 14–16 cm. a Potter-Bucky diaphragm also must be used to obtain good contrast.

Positioning is a matter of getting what is wanted on the film at the most suitable angle. Positioning should be done with meticulous care with each exposure, not only to obtain the best possible picture, but also to be able to duplicate it and to become familiar with one view of a region. The importance of accurate positioning cannot be over-emphasized. Many an otherwise good film is made practically valueless by rotation into an unfamiliar position, producing questionable and easily mistaken appear-

ances. It is well to mention in this connection the value of oblique films, especially the left anterior oblique, in any study of the heart. It is not a rare experience to have the left anterior oblique view of a heart change the impression formed from the single posteroanterior view. The value of stereoscopic films in chest examinations and also in studies of the pelvic girdle, spine, shoulders, skull, etc., is now quite well recognized but still needs emphasizing.

Film processing is so well handled in manufacturers' literature that it is not necessary here to do more than emphasize the importance of the dark room and urge that the manufacturers' directions be followed to the letter. Controlled time-temperature development is well worth the additional expense for apparatus.

Working from these ideas, it is possible to develop several charts, each with only one variable factor (the peak kilovoltage), which will cover the field of diagnostic roentgen technique.

Let us first consider roentgenography of the extremities. An adult can be expected to remain quiet, and if necessary to hold his breath, for as long as five seconds. As detail is most important, the smallest focal spot, about 1.5 cm., should be used, and this will carry 20 ma. for this time. A satisfactory tube-film distance for this work is 76 cm. On suitable graph paper centimeters are marked off along the abscissa and kilovolts (peak) along the ordinate, starting at about 20 kv. (peak). With these factors several films of a 3 cm. hand, for instance, are taken, without screens, trying different kilovolt (peak) settings. Having determined the optimum kilovolt (peak), a dot is marked on the chart and the experiment is repeated with a knee about 10 cm. thick. Now we have two correct kilovolt (peak) settings—for 3 cm. and 10 cm. A straight line is run through these points and the chart is complete. Any other control panel data for the particular apparatus in use, such as primary volt settings, filament settings, etc., may be noted beside the kilovolts (peak). A second line may be drawn in on this same chart to cover screen work,

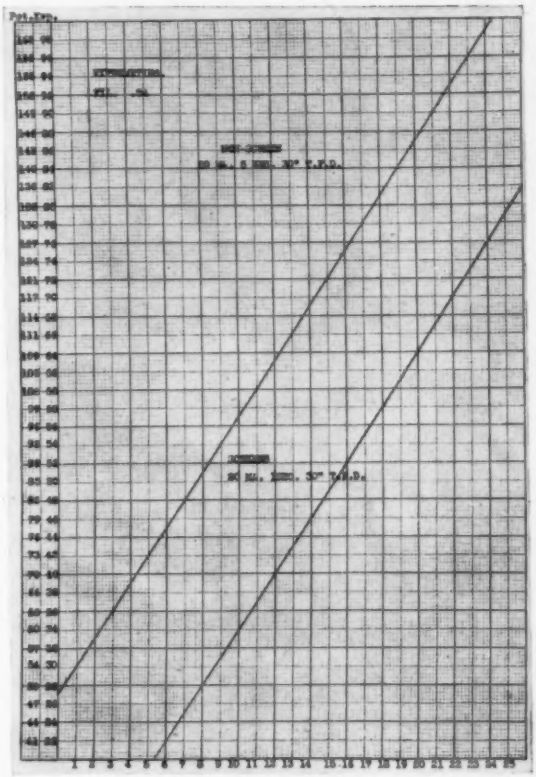

Fig. 1. Extremities.

using 1 sec. exposure but other factors the same as for non-screen technique. If, now, there is an 8.5 cm. ankle to be roentgenographed locate 8.5 cm. on the abscissa, determine where the vertical from this point intersects the graph, and run left from this point to the ordinate where the appropriate kilovolts (peak) will be found. The control figures entered on the chart beside the kilovolts (peak) give complete data for the desired technique (Fig. 1).

For gastrointestinal examinations ½ sec. "stops" motion very satisfactorily. It is best to use 100 ma. for this, with proper tube; and cone, screens and a Potter-Bucky diaphragm are needed for a good roentgenogram. This chart is laid out in the same way as the preceding one, starting with the least thickness that may be encountered and the lowest peak kilovoltage that will be needed. This same chart may be used for genitourinary and gallbladder work (Fig. 2).

For examinations of the spine time is not important, while definition is essential,

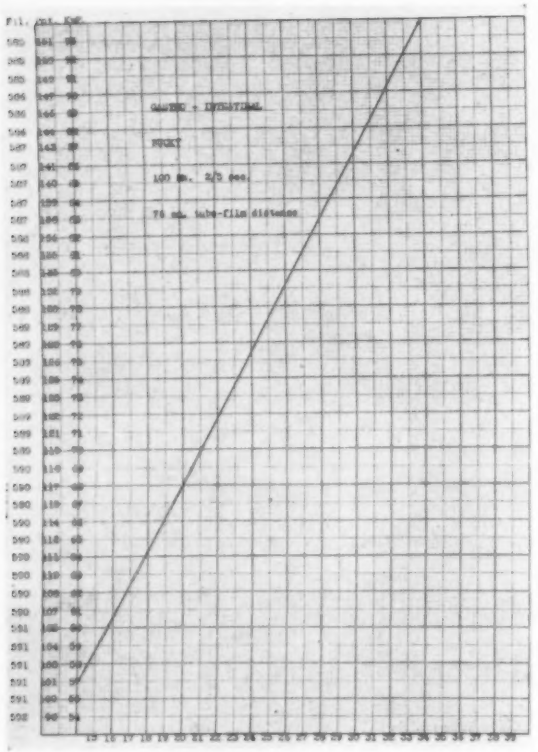

FIG. 2. Gastrointestinal.

so the smallest focal spot is used. A compression band makes a 10 sec. exposure possible and 15 ma. will not overload the tube for this length of time. Cone, screens and Potter-Bucky diaphragm are necessary. Again a chart is laid out and different kilovolt (peak) settings are tried until the line is correctly drawn in for anteroposterior films of the dorsal and lumbar areas. For lateral dorsal films a separate line is needed, about 10 kv. (peak) lower than the line for anteroposterior views, since the total radiodensity in the lateral dorsal view is considerably less than in the anteroposterior because of the presence of air-containing lungs. For the lateral lumbar view the time can be increased about 3 sec. to avoid increase in peak kilovoltage (Fig. 3).

For chests the shortest exposure time, up to 1/30 sec., that will give satisfactory films with the milliamperage available should be used, so the full milliamperage capacity of the apparatus will be needed. A tube-film distance of 2 meters is preferable, but 125 cm. may be used if the power of the apparatus does not permit the use of the longer distance. Less than 125 cm. is not satisfactory. Cone and screens are needed, but as yet we have not found the Potter-Bucky diaphragm practical for routine chest roentgenography. The chart for chest roentgenography is laid out like the others. A second line is needed for the left anterior oblique and right anterior oblique positions with the kilovolts (peak) about 12 higher than the posteroanterior line, since the posteroanterior measurement can be used to determine the left anterior oblique and right anterior oblique settings (Fig. 4).

The sinus and skull chart is rather complicated. Detail being of greatest importance, the smallest tube is used, with 20 ma. and a 5 sec. exposure, at a suitable tube-film distance. There are advantages in keeping the tube-film distance the same in all operations except chest roentgenography. Cone and screens are needed. The Potter-Bucky diaphragm gives improved

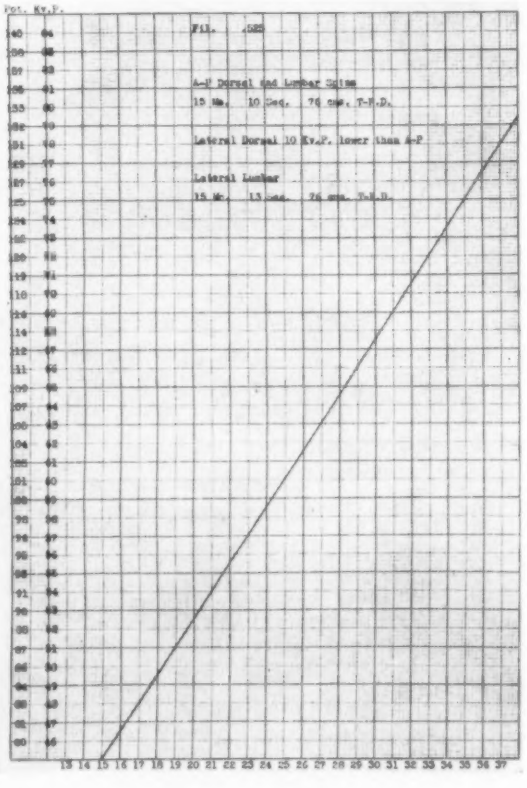
Fil. .025
A-P Dorsal and Lumbar Spine
15 Ma. 10 Sec. 76 cms. T-F.D.
Lateral Dorsal 10 Kv.P. lower than A-P
Lateral Lumbar
15 Ma. 13 Sec. 76 cms. T-F.D.

FIG. 3. Spine.

contrast but is not necessary. A chart to cover all positions must include several lines, as the peak kilovoltage needed for proper penetration varies in the different positions because of differing proportions of bone (Fig. 5).

These five charts will cover all ordinary diagnostic work, with some variations of peak kilovoltage as experience dictates and differences from average build demand. In chest roentgenography especially it may be found necessary to vary as much as 4 or 5 kv. (peak) above or below the line for unusual builds. Measurements should be carefully and accurately made with proper calipers and should be recorded along with the technique data for future reference.

Several charts are shown which are at present in use with a three-phase, 1,000 ma. outfit. They are covered with washed film base and kept in a loose-leaf notebook along with tube rating charts and other data to which we have occasion to refer frequently. The scheme has been in use in this laboratory for about two years and has worked out very well.

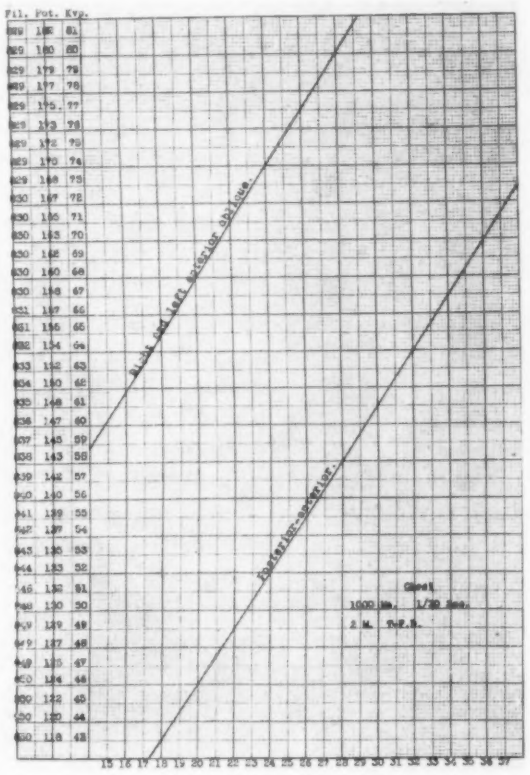

Fig. 4. Chest.

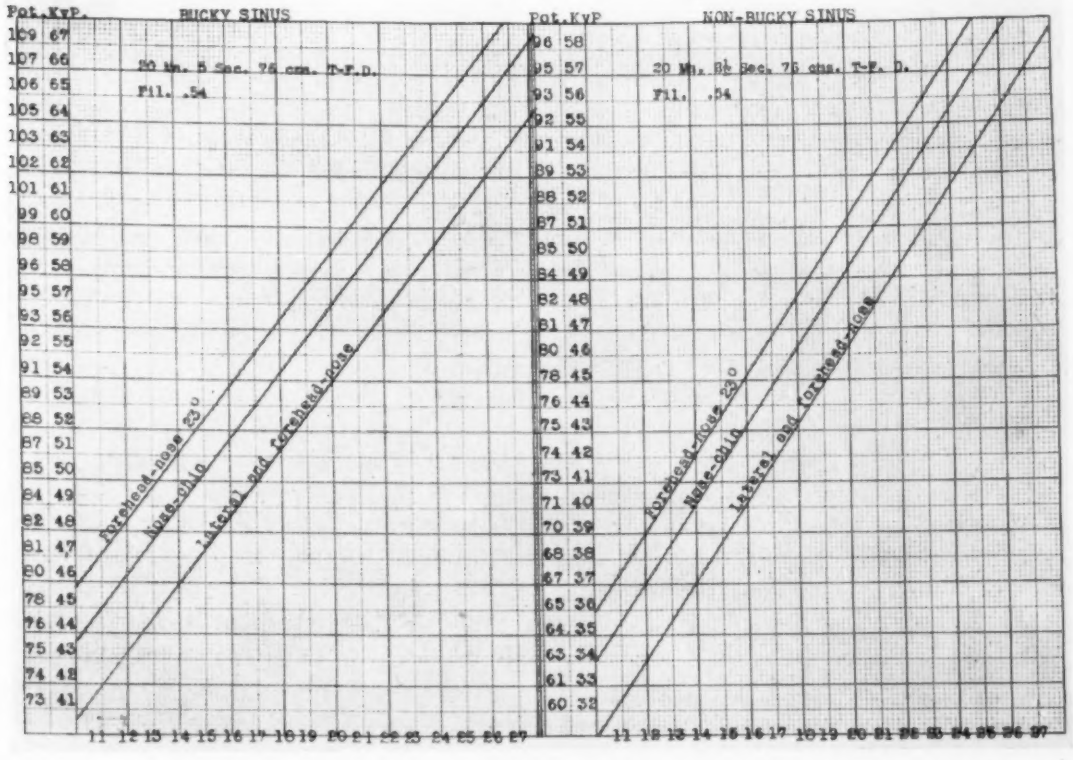

Fig. 5. Sinuses.

MILLION VOLT ROENTGEN-RAY PROTECTION

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A NEW type of apparatus for the production of supervoltage roentgen rays, designed by the high voltage research group of the Massachusetts Institute of Technology and installed at the Collis P. Huntington Memorial Hospital, was recently described.[1] This apparatus has been in successful operation at a constant potential of more than 1,000,000 volts since February, 1937.

The generator is of the electrostatic belt-conveyor type and is housed in a specially designed structure appended to the main hospital building. Complete protection from direct and scattered radiation is secured by terminating the multisectional porcelain tube in a treatment room which is entirely below ground. It is our belief that this is the best method of installation. However, should supervoltage generators of this high capacity become available in more compact form, it might in some instances prove desirable to place both generator room and treatment room at ground level or above ground level. The protection of those working in close proximity to the apparatus from harmful amounts of radiation would then become an important problem. It therefore seems desirable to investigate the efficacy of two of the materials commonly employed for roentgen-ray protection, namely, lead and cement.

In order to measure small radiation intensities, a cylindrical "air wall" chamber of large volume (680 cc.) was constructed. This was calibrated by placing it at a distance of 8.8 meters from a 200 kv. roentgen-ray source whose intensity in roentgens at 50 cm. had been accurately determined by a smaller, less sensitive ionization chamber. The amount of radiation arriving at the large chamber was calculated by the inverse square law, and the discharge time of the electroscope to which the chamber was attached was noted. Each of the 50 divisions on the electroscopic scale was found to represent 1/1,000 of a roentgen. Linear readings of the instrument were obtained with variations of intensity and exposure time. The natural leak of the electroscope was found to be less than 1 milliroentgen in twelve hours, which was considered negligible.

All intensity measurements, both of direct and scattered radiation, were made with the supervoltage machine operating as follows: 1,000 kv.; 1.2 ma.; 5 mm. lead equivalent filter; output at 70 cm., 70 r per minute; half-value layer of copper 13 mm. Measurements of direct radiation were made free in air with the ionization chamber at a distance of 70 cm. from the anode. Measurements of scattered radiation were made with a 25 cm. pressdwood phantom located 70 cm. from the anode and exposed through a 20 by 20 cm. portal, chamber-anode distance 7 to 8 feet (see below).

In order to determine the amount of lead necessary to absorb the direct radiation, a measurement was first taken after the rays had traversed a 3-inch lead shutter used normally for starting and stopping treatments. An intensity of 32 milliroentgens per minute was recorded. Additional layers of lead in the form of 1/2 inch slabs were then interposed between the anode and the ionization chamber. The results are recorded graphically in Figure 1. It will be noted that 5 1/2 to 6 inches of lead are necessary for adequate protection from the direct rays. Approximately the same thickness of lead is commonly employed for radium protection.

For the purpose of measuring scattered radiation, the ionization chamber was first placed within the treatment room at a distance of 7 feet from the anode; 14.4 milli-

[1] Dresser, R., Trump, J., and Van de Graaff, R. J. Production of supervoltage roentgen rays by means of an electrostatic generator. AM. J. ROENTGENOL. & RAD. THERAPY, 1937, *38*, 758–761.

roentgens per minute were delivered to the chamber. The chamber was then placed outside the treatment room at a distance of 8 feet from the anode behind a door covered with 1/2 inch lead. An electroscopic discharge at the rate of 6 milliroentgens per hour was observed. The chamber was next located behind a cement wall 1 foot thick covered by 1/2 inch lead at a distance of 8 feet from the anode. There was no discharge of the electroscope after operation of the roentgen apparatus for one-half hour. Further measurement of scattered radiation was made with the chamber outside the treatment room behind a cement wall 1 foot thick, but without lead covering. The discharge of the electroscope after operation of the machine for one-half hour was negligible.

For purposes of comparison, measurements were made with the chamber placed in a 200 kv. therapy room at a distance of 7 feet from the anode. The apparatus was operated at 200 kv. constant potential; 8 ma.; 0.5 mm. copper filter; 20 by 20 cm. portal; 50 cm. distance; 25 cm. pressdwood phantom in place. Normal output at 50 cm., air measurement, was 20 r per minute. The roentgen tube was enclosed in a modern "shock-proof" head. Scattering at the rate of 8.8 milliroentgens per minute was recorded. The chamber was then placed outside the 200 kv. therapy room behind a 1/4 inch lead wall. The electroscope discharge at the end of one-half hour's operation was negligible. For further comparison, the chamber was located in the roentgenoscopic room at the mid-abdominal level of the operator with the roentgenoscopic table in the horizontal position. A pressdwood phantom occupied the position of the patient, and the apparatus was run at 85 kv., 5 ma., with a roentgenoscopic field 6 by 8 inches. A discharge of 10 milliroentgens per minute was obtained.

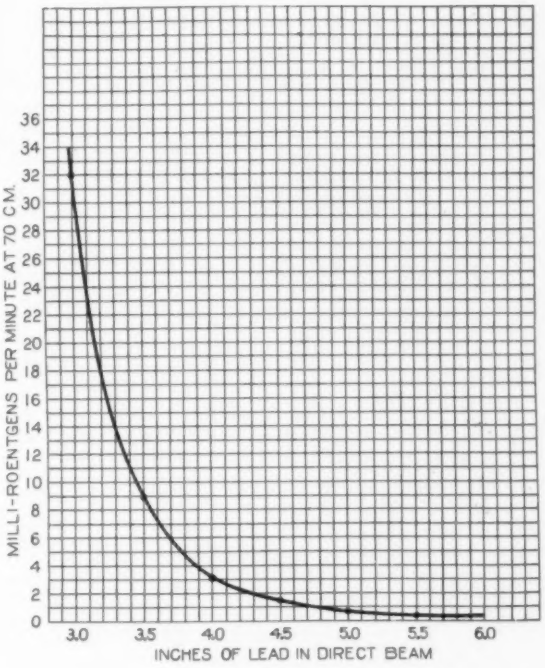

Fig. 1. Absorption in lead of direct beam of roentgen rays produced at one million volts constant potential.

CONCLUSIONS

(1) Five and a half to 6 inches of lead absorb most of the direct radiation from a 1,000 kv. constant potential source and may be considered to afford adequate protection.

(2) One-half inch lead does not give complete protection from scattered radiation at 1,000 kv. One foot of cement is better, and 1 foot of cement plus 1/2 inch of lead we believe to be entirely safe.

(3) The intensity of the scattered radiation from a commercial "shock-proof" unit operating at 200 kv. constant potential is approximately twice as great as that from our 1,000,000 volt unit. However, 1/4 inch of lead is sufficient to give complete protection from the 200 kv. radiation.

(4) It is well known that the roentgenologist is exposed to large amounts of scattered radiation during roentgenoscopy. Our measurements indicate that this intensity may be as high as 1/100 of a roentgen per minute. During the course of eight or ten gastrointestinal examinations the operator may receive as much as 0.2 r. The wave length of this type of radiation is, however, much longer than that resulting from higher voltages, and the systemic effects presumably less.

INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

Skeletal System

BOWERS, R. F.: Myositis ossificans traumatica 975

MIDDLETON, W. S., POHLE, E. A., and RITCHIE, G.: Lymphosarcoma of mediastinum with metastases to skeleton 975

ALLDREDGE, R. H.: Ainhum (dactylolysis spontanea) 975

LOVE, J. G., and CAMP, J. D.: Root pain resulting from intraspinal protrusion of intervertebral discs 975

MILCH, H.: Epiphysiolysis or epiphyseal coxa anteverta 977

KARP, M. G.: Köhler's disease of tarsal scaphoid 978

BLOUNT, W. P.: Tibia vara 978

LIBERSON, F.: Os acromiale 978

FERGUSON, A. B.: Roentgenography of tuberculosis of joints 979

BENNETT, G. A., and BAUER, W.: Joint changes resulting from patellar displacement and their relation to degenerative joint disease 980

WALKER, H., and BLOOM, N.: Multiple myeloma 980

SCHENCK, S. G.: Hodgkin's disease with bone manifestations 980

WEIDMAN, F. D., and STOKES, J., JR.: Extensive xanthoma tuberosum in childhood due to infectious cirrhosis of liver 980

BAKWIN, H., and KRIDA, A.: Familial metaphysial dysplasia 981

LOWENBURG, H., SR., SHIELDS, W. P., and TURNOFF, D.: Scurvy with an unusual symptom 981

CHOWN, B., and LEE, MARGARET: Renal rickets and dwarfism as a pituitary disease 981

BERGSTRAND, H.: Four cases of Ewing sarcoma in ribs 982

REHBOCK, D. J., and HAUSER, H.: Liposarcoma of bone 982

FARIÑAS, P. L.: Differential diagnosis of bone tumors of extremities by arteriography 982

ROENTGEN AND RADIUM THERAPY

KNIERER, W.: Experiences with close roentgen irradiation in carcinoma of skin 982

SETTLE, F. B.: Cancer of the thyroid gland 983

NICHOLSON, W. P., and BERMAN, M. D.: Carcinoma of breast 983

SIMMONS, C. C., TAYLOR, G. W., and ADAMS, H. D.: Cancer of breast 984

FÜSSL, E.: Observation on radiation therapy of metastatic carcinoma of lungs 984

MAYTUM, C. K., and LEDDY, E. T.: Roentgen therapy for severe asthma 984

SCHINDLER, R.: Chronic hypertrophic ulcerative gastritis treated by Coutard's method of roentgen therapy 984

PRATHER, G. C., and FRIEDMAN, H. F.: Immediate effect of preoperative radiation in cortical tumors of kidney 984

ANDREWS, J. R., and UHLE, C. A. W.: Carcinoma of urinary bladder 985

FRIEDMAN, A. B., and SELIGMAN, B.: X-ray therapy in amenorrhea 985

GOOD, F. L.: Menorrhagia and metrorrhagia of benign origin in women under forty-five years of age 985

RICHMAN, S., and SELINSKY, H.: Schwannoma of cauda equina 985

MISCELLANEOUS

MARSHAK, A., and BOLLMAN, V. L.: Absorption of x-rays by sperm and erythrocytes and its relation to susceptibility of tissues to x-rays 985

DES LIGNERIS, M., and GRASSET, E.: Clinical experiments on effect of African snake venoms on human cancer cases with or without concomitant deep therapy 986

WOODHOUSE, D. L.: Chemotherapy investigations in cancer 986

JORDAN, H.: Roentgen analysis of spine 986

HUDSON, J. C.: Dependence of x-ray erythema on wave length 986

ECKERT, C. T., PROBSTEIN, J. G., and GALINSON, S.: Radiation of the thyroid 986

ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

SKELETAL SYSTEM

Bowers, Ralph F. Myositis ossificans traumatica. *J. Bone & Joint Surg.*, Jan., 1937, *19*, 215–221.

In treating myositis ossificans traumatica, Bowers states that three types of cases must be taken into consideration, as follows: (1) those cases in which no treatment is necessary; (2) those in which conservative treatment alone suffices; (3) those in which operative interference is necessary.

The first group, which is probably the most frequent type, is that in which, following minor injuries to the thigh and the buttocks, small calcified, symptomless areas are discovered in the muscle during examination for other conditions. These are probably the result of contusions or of subperiosteal hemorrhages, and in the organization that follows, by means not clearly understood, calcification takes place. This type does not need treatment.

The second type presents more extensive calcified areas with definite symptoms and a mass, which is sometimes tender and which occasionally causes a certain amount of disability. Usually during a period of five to twelve months after the appearance of the mass, gradual absorption and ultimate disappearance without symptoms, takes place. Bowers had the opportunity to follow one of these cases, observing the softening of the mass and the beginning of its disappearance, and finally making a pathological examination of the entire mass five months after the original injury.

The third type includes those cases in which the mass is usually located in the region of the joints, disabling the patient by ankylosis or limitation of joint motion and in which, after the proper period of observation, absorption does not occur. In the treatment of this type, Bowers emphasizes the necessity of operation.

Comparison of the pathological findings showed a predominant number of giant or osteoclastic cells in the case in which absorption took place, while in a case demanding operation, not one of these cells was present. The pathological picture clearly parallels the clinical observations.—*R. S. Bromer.*

Middleton, William S., Pohle, Ernst A., and Ritchie, Gorton. Lymphosarcoma of the mediastinum with metastases to the skeleton. *Am. J. Cancer*, Nov., 1936, *28*, 559–564.

A case of lymphosarcoma is described because of the diagnostic problem and the conflicting responses to roentgen therapy observed. The primary lesion in the mediastinum was first mistaken for dissecting aneurysm. The enlargement of the mediastinal mass under deep roentgen therapy was found at autopsy to be due to necrosis and hemorrhage into the mass, in which only a few viable tumor cells were found. Small doses of roentgen therapy to the metastatic areas in the right shoulder and right pelvis gave immediate relief from pain.—*J. S. Weber.*

Alldredge, Rufus H. Ainhum (dactylolysis spontanea). *J. Med. Ass. Alabama*, Oct., 1936, *6*, 137–141.

A case of ainhum with roentgenological, pathological and laboratory studies is reported. The roentgen findings vary with the stage of the disease, the bone showing a rarefying osteitis. The author's case presented two conditions not previously mentioned: associated exostoses on the terminal phalanges of the great toes and the involved phalanx in the little toe not only showed the usual findings but also showed a definite elongation of the middle, or involved, phalanx. The joint space of the terminal interphalangeal joint was also wider than the normal.—*W. R. Brooksher.*

Love, J. Grafton, and Camp, John D. Root pain resulting from intraspinal protrusion of intervertebral discs. *J. Bone & Joint Surg.*, July, 1937, *19*, 776–804.

This report is based on a careful study of the records of 50 consecutive patients who have been operated upon at the Mayo Clinic for protrusion of one or more intervertebral discs, producing either root pain, or symptoms and signs of compression of the spinal cord. The literature is reviewed, the etiology, pathology and symptoms are discussed in detail. The patients were selected from a large number of

individuals who came to the Clinic with various types of chronic pain. For the most part the pain resembled that which results when a spinal nerve is compressed. There was not a postoperative death in the series. The authors consider that protrusion of an intervertebral disc is a definite anatomical and pathological condition. It is usually the result of a trauma which may be slight or severe. The most common symptom of such protrusion is pain along the course of one or more spinal nerves, most often the sciatic nerve.

Ordinary roentgenograms are of little value in the diagnosis of this condition. In one case the lesion was partially calcified and ossified and was clearly visible within the spinal canal just posterior to the body of the seventh cervical vertebra. In 15 cases with a narrowed fourth or fifth lumbar intervertebral space, a corresponding surgical lesion was demonstrated in nine. In 17 cases there was evidence of hypertrophic changes about the margins of one or more intervertebral joint spaces but in only 5 cases, however, were there hypertrophic changes localized about the margins of the intervertebral joint space at the site of the lesion. A compression fracture of one or more vertebral bodies occurred in only 3 of the patients and in 2 of them the protruded disc was remote from the level of the compression fracture. In 14 cases lipiodol injection was not carried out; 9 of these patients were operated upon prior to 1930 and 5 in subsequent years. The neurological examination in every case clearly established the level of the lesion. Operation was carried out directly with the expectation of finding a tumor affecting the spinal cord.

The lumbar injection of lipiodol is preferred. After injection, the patient is placed in a sitting position on the fluoroscopic table for about one minute in order to permit all of the oil to gravitate to the sacral cul-de-sac. This being done, the patient is placed in the prone position on a tilting fluoroscopic table with the foot end of the table depressed to prevent cephalad excursion of the oil until the actual fluoroscopic observation is started. The shoulders are supported by padded shoulder rests. If the oil is seen to be low down in the lumbar canal, the foot of the tilting table is gradually elevated and the shadow of the oil as it moves cephalad is carefully observed. When the pupils are properly dilated it is easy to recognize the intervertebral joint spaces and to observe their relation to any defects that may appear. If the symptoms indicate that the lesion involves the lumbar roots, it may not be necessary to observe the movements of the oil above the conus medullaris. Since protruding discs are situated in the anterior portion of the spinal canal, they produce their maximal filling defect when the patient is lying prone. In this position the heavy oil will gravitate to the ventral aspect of the subarachnoid space and is in close contact with the protruding disc. If a persistent defect is observed, films should be exposed as quickly as possible without disturbing the position of the patient. The most satisfactory film is obtained when a film is substituted for the fluoroscopic screen and the exposure made with the tube beneath the table. This is extremely important, for if one wishes to have a record on films of the fluoroscopic image, which the authors consider the most significant part of the examination, it is necessary to have some means of roentgenographing the lipiodol "on the move." Fluoroscopic examination should include observations in the prone-oblique and lateral positions. Only by this means is it possible to determine accurately the anterior or anterolateral position of a mass that indents the column of lipiodol. After the excursion of lipiodol has been studied in the foregoing positions, the authors have the patient, routinely, sit up again for one minute in order to collect the oil in the sacral cul-de-sac, and then repeat the examination with the patient supine.

Because the protruded fragment of the disc is extradural, it will push against the column of lipiodol in the subarachnoid space, on the ventral or ventrolateral aspect, and indent it or displace it posteriorly and sometimes laterally. Complete obstruction of the column of lipiodol was observed in the case of large protrusions. The classic filling defect is a sharply defined, rounded indentation in the lipiodol shadow on one side of the midline, opposite an intervertebral disc. In 22 cases the defect was unilateral, on the right side in 10 and on the left in 12. The defect was bilateral in 12 patients. In 6 cases, multiple defects were observed. In 1 case, the lateral view was the only position which revealed the defect. In addition to the outline of the defect produced by the mass of the protruded disc, significant changes in the shadows of the nerve roots may be present at the level of the lesion. These consist of

edema of one or more roots, which may be recognized by a broadening of the negative shadow of the nerve root if it is outlined, and by displacement or deformity of the shadows of nerve roots within the subarachnoid space. If the oil has extended into the extradural portion of the nerve sheath, displacement or deformity of this root may occasionally be visible. In some distances in which several nerve sheaths were visible, it was noticed that there was persistent non-filling of the sheaths on the side of the lesion, suggesting possible pressure or edema of the nerve. This is not a reliable sign of protrusion of the disc, however, as nerve sheaths fill so inconsistently.

Intraspinal neoplasm must be differentiated. Other conditions which most closely resemble protrusion of the intervertebral disc are: low-back pain (whatever its cause), lumbosacral strain, sacroiliac disease, spondylitis and hypertrophic changes involving the spine. Likewise, brachial plexus or lumbosacral plexus neuritis may be the diagnosis in a given case until the examination of the spinal fluid reveals an increased total protein, and fluoroscopic study with lipiodol then discloses the real cause of the painful condition.

The treatment of choice is laminectomy, with removal of the protruded portion of the disc. Decompressive operations without removal of the disc are not advised.—*R. S. Bromer.*

Milch, Henry. Epiphysiolysis or epiphyseal coxa anteverta. *J. Bone & Joint Surg.*, Jan., 1937, *19*, 97–116.

It is Milch's opinion that so-called epiphysiolysis is of the nature of a torsional fracture at the cervicocapital junction of the femur. The essential element in the production of the condition is the gradual and progressive anteversion of the neck of the femur. This is so characteristic that he thinks the disease should be renamed "coxa anteverta."

He divides the progress of the condition into three stages. The first stage is the "preslipped stage" and the roentgenograms are usually negative. This, however, is the period during which the loosening or lysis at the epiphyseal plate is taking place. As the external rotation or eversion of the leg increases, the capital epiphysis follows until it reaches the limit of motion which the ligamentum teres permits. Later widening of the epiphyseal line may appear in the roentgenogram and lateral films may show that the apparent widening of the epiphyseal line is caused by a gradual true anteversion of the upper or proximal end of the neck of the femur, and that the "preslipped" stage is characterized by a slipping which occurs only in an anteroposterior plane.

The anteroposterior roentgenogram in the second stage shows characteristic upward displacement of the shaft of the femur. In this phase the head is not rotated in any particular manner. It is retained in its normal position in the acetabulum and is usually of normal height. The shaft is seen to be surmounted by an elliptical shadow which varies in diameter with the degree of external rotation of the extremity. The shaft may be rotated either internally or externally without materially or regularly affecting the position of appearance of the head in the acetabulum. This independent motion is pathognomonic of the second phase of the disease. Its appearance marks the beginning of this phase; its disappearance marks the end of the second stage and the onset of the third or final period.

The third stage is that of fracture healed in malposition. Stereoscopic roentgenograms and other views establish the fact that the neck is anteverted and that the head is situated upon the upper posterior edge of the neck. Roentgenograms showing internal and external rotation demonstrate that the motion of the shaft entails a corresponding motion of the head with variation in the apparent size of the capital epiphysis and of the subcapital elliptical shadow. This Milch regards as the pathognomonic sign of the end stage of the affection.

Treatment in the first stage (anteversion) should be dominated by preventive efforts; in the second stage (fracture) by restorative or reductive efforts; and in the third stage (malunion), by rehabilitative or reconstructive efforts. The fundamental principle involved in the treatment of the disease lies in the prevention of the excess anteversion. This may be done by means of a brace with a pelvic girdle attachment, in order to maintain internal rotation of the leg. In cases in which anteversion has proceeded to the point where the weight can no longer be supported and fracture with upward displacement of the shaft has occurred, reduction of the displacement under roentgenographic control and immobilization is recommended.—*R. S. Bromer.*

KARP, MEIER G. Köhler's disease of the tarsal scaphoid; an end-result study. *J. Bone & Joint Surg.*, Jan., 1937, *19*, 84–96.

Karp's paper is an analysis of 45 cases of Köhler's disease of the tarsal scaphoid treated at the Children's Hospital, Boston, during the past ten years. Roentgenograms showing complete healing and return to normal bone structure were available in 19 cases.

This syndrome occurs predominantly in male children between the ages of two and one-half and seven and one-half years, and is manifested by pain, a limp, swelling, and localized tenderness in the foot. It is more frequently unilateral than bilateral and has a characteristic roentgen appearance which is unrelated to duration of symptoms or treatment. Complete regeneration of the involved bone takes place in an average of two and three-fourths years, and a normal foot is the usual end-result.

Karp discusses the development of the scaphoid in detail and includes in his illustrations a series of roentgenograms to show the characteristics of the accelerated, normal and retarded scaphoids in both boys and girls. The average for the appearance of the osseous nuclei in the roentgenogram may be considered to be between eighteen months and two years in girls, and between two and one-half and three years in boys. He suggests that retarded development of the osseous nucleus of the scaphoid may alter its density, outline, and configuration, so as to simulate the picture of Köhler's disease.—*R. S. Bromer.*

BLOUNT, W. P. Tibia vara; osteochondrosis deformans tibiae. *J. Bone & Joint Surg.*, Jan., 1937, *19*, 1–29.

In this paper Blount collected 15 cases from the literature and added 13 new cases to illustrate the occurrence of an ostochondrosis similar to coxa plana and Madelung's deformity, but located at the medial side of the proximal tibial epiphysis. This condition has been variously designated as rickets, chondrodysplasia, a growth disturbance, an unusual epiphyseal change, an epiphyseal defect, osteitis of the upper end of the tibia and as an unknown disease. It is not an inflammation, and in accordance with the more recent usage, the name should not contain the suffix "itis." It is not limited to the epiphysis, but is an abnormality of growth of the metaphysis, epiphyseal cartilage, and osseous center of the epiphysis. As a result of the condition, abrupt angulation with varus and back-knee and internal rotation of the leg occurs and this is usually confused with rickets. The roentgenographic and pathological changes are like those of coxa plana and similar to those of chondrodysplasia, but are quite different from those of rickets.

The changes may appear in the first year or two of life (infantile type) as a developmental exaggeration of the normal, with sloping epiphysis and beak-like recurving metaphysis. A similar deformity may occur just before puberty (adolescent type), secondary probably to local trauma or possibly infection. The age is more important than the causative factor in determining the roentgenographic appearance. In the infantile group the characteristic roentgen findings are: (1) the abrupt angulation just below the proximal tibial epiphysis; (2) the medially expanded, sometimes irregular, epiphyseal line; (3) the wedge-shaped epiphysis; (4) the prominent, beak-like, recurving medial metaphysis; (5) the cartilage islands within the beak. In the adolescent type the characteristic roentgen findings are the sloping epiphysis and beak-like recurving metaphysis. Roentgenographically the infantile type can be observed gradually to change into the adolescent type so that the two can be distinguished later only by the history of the patient.

Treatment should be directed, Blount believes, toward the mechanical relief of strain until the deformity is stationary or until the epiphysis is closed. A simple osteotomy is desirable in the correction of marked deformity. If it is done before the amount of angulation has become stationary, some degree of recurrence may be anticpiated.—*R. S. Bromer.*

LIBERSON, FRANK. Os acromiale—a contested anomaly. *J. Bone & Joint Surg.*, July, 1937, *19*, 683–689.

Liberson states that a paucity of material exists in the English literature on the os acromiale. He reviewed the anatomical references and other articles on the subject, and found a wide divergence of belief in the frequency of the condition. The os acromiale appears as a fragment lying at the outer end of the acromion process. Anatomically it has been classified under four principal types. The most frequent is the quadrangular; the next, the oval; third, the triangular; and, rarely, the falciform. The os acromiale is best demon-

strated in roentgenograms in the inferosuperior plane.

The roentgenographic appearance of the os acromiale is not uniform because its irregularity in size, shape, position and mode of articulation with the clavicle is due to the random chance formation of the bone. It is seen as a separate shadow, roughly triangular in shape, varying in size, and appearing to sit unevenly astride the angle of the acromion. In the usual anteroposterior views, the transverse axis is about three times as long as the vertical diameter, and is usually tilted inward for about 15° from the horizontal toward the upper lip of the crest of the spine. The density of the upper half of the shadow is the same as that of the lateral end of the clavicle; the lower half shows two dense lines with or without a darker linear shadow between these two lines. The upper line is horizontal and represents the basal part of the acromion which is continuous with the spine at the angle where the crest and the lateral border of the spine meet; the lower line is oblique, upward, and outward, and represents the basal part of the os acromiale which has failed to fuse with the rest of the acromion. There may be more than two lines, as in a typical case, but there must be at least two; otherwise, each downward projected acromial end would be taken for an os acromiale. The median border is sharply linear and denser, usually parallel to the adjacent long diameter of the clavicle forming with it a joint space between the os acromiale and the clavicle. The superior border is convex, continuous with the medial border internally.

In regard to the differential diagnosis between the presence of an os acromiale and a fracture, the following points are useful:

1. It occurs bilaterally in about 62 per cent of cases.

2. The borders of the suspected fragment are rounded and the cleavage line is uniform in the case of the os acromiale, whereas the borders are sharp and the cleavage line is ragged in the case of a fracture.

3. The position of the shadow is at the same or a higher level than the remaining part of the acromion in the case of an os acromiale, whereas the position of the shadow is at a lower level in the case of a fracture.

Pointed borders may indicate an associated osteoarthritis. Also fractures of the acromion are less frequent and the majority of them are associated with other minor fractures of dislocations of the shoulder girldle.—*R. S. Bromer.*

Ferguson, Albert B. Roentgenography of tuberculosis of the joints. *J. Bone & Joint Surg.*, July, 1937, *19*, 653–656.

Ferguson states it is a common roentgenographic practice to produce films designed to show the bones only, the soft tissue shadows being much too dark for intelligent study. Bone shadows are not particularly useful in differential diagnosis unless supplemented by soft tissue shadows of effusion, swelling, infiltration, atrophy, relative density, etc. Changes in bone in most lesions come too late to really aid in the solution of the diagnostic problems.

In tuberculosis, effusions and soft tissue abscesses tend to be as dense as adjacent muscle shadows, sharply outlined, and centered on the lesion or elongated in the planes of the involved tissue. The differentiation of tuberculosis from other infections is a matter of perceiving the characteristic expression of chronic and progressive development of effusion, soft tissue atrophy, decalcification and thinning of the cartilage space without calcifying reaction. One must see that these features are present in the degree and in the relation to each other which express the tendency to their chronic and progressive development. When this picture is evident, the lesion is probably tuberculous, but, before that diagnosis is made, it is necessary to consider the circumstances under which the lesion has developed. This is the only way to identify other infections which may imitate the picture of tuberculosis, or tuberculous lesions which may simulate other infections.

Among the circumstances of the lesion which are important in the diagnosis of tuberculosis and which should, therefore, be known before attempting that diagnosis in a given case are:

1. The duration, which affects the amount of effusion, atrophy, decalcification, and thinning of the joint space, particularly.

2. The previous treatment. Immobilization limits or reduces effusion and increases atrophy. Aspiration reduces effusion. Surgical procedures may alter the picture in various ways.

3. The age of the patient. Decalcification tends to be more prominent and more marked in children than in adults, but it may appear more quickly in the latter.

4. The virulence of the lesion. If the patient

is not greatly affected by the lesion, atrophy and decalcification are less than when the functioning of the limb has been very much affected.

5. The presence of sinuses which may allow the development of secondary infection and the superimposing of pyogenic features on the tuberculous picture.

These are the most important considerations but the more difficult the diagnostic problem the more neecssary it becomes to know even more fully all of the circumstances of the case. —*R. S. Bromer.*

BENNETT, GRANVILEE A., and BAUER, WALTER. Joint changes resulting from patellar displacement and their relation to degenerative joint disease. *J. Bone & Joint Surg.*, July, 1937, *19*, 667–682.

This paper presents the result of a study undertaken to determine the effects of patellar displacement in knee joints which had not been opened surgically or traumatized in any other manner, and to compare the changes produced with those found in human knee joints with displaced patellae.

The author's summary follows:

1. The patellae of rabbits can be displaced without opening or otherwise injuring the knee joint. Such patellar displacement is of itself adequate cause for degenerative and hypertrophic changes in cartilage, similar to those of degenerative joint disease.

2. The undue pressure and friction of the displaced patellae resulted in rapid loss of the underlying articular cartilage with subsequent eburnation of the subchondral bone.

3. The absence of normal patellar apposition and, in consequence, of lubrication of the non-articulating surfaces with synovial fluid was responsible for articular-cartilage degeneration and atrophy.

4. Proliferation of the connective tissue at the perichondral margins of the articular surfaces led to well defined marginal overgrowth. This marginal overgrowth was sufficiently marked to form a new patellar articulating surface on the medial side of the femur.

5. The repeated stretching of the synovial membrane at its insertion, coincident with full extension, would seem adequate stimulus to cause the very vascular, undifferentiated, perichondral connective tissue to proliferate sufficiently to result ultimately in marginal lipping. Such marginal proliferation occurs to some degree in all joints with increasing age and long-continued use but develops much more rapidly in joints with anatomical derangements such as patellar displacement.

6. The clinical and pathological findings from one patient with bilateral displacement of the patella were identical with those of degenerative joint disease.

7. These studies emphasize the importance of early corrective measures in patients with displaced patella if irreparable joint damage is to be prevented.—*R. S. Bromer.*

WALKER, HARRY, and BLOOM, N. Multiple myeloma: A report of five cases. *Virginia M. Monthly*, Jan., 1937, *63*, 616–621.

The authors report 5 cases of multiple myeloma, stressing the protean manifestations of the lesion, and emphasizing the importance of biopsy and the roentgen ray in exact diagnosis. —*W. R. Brooksher.*

SCHENCK, SAMUEL GEORGE. Hodgkin's disease with bone manifestations. *New York State J. Med.*, Jan. 1, 1937, *37*, 27–37.

Granulomatous invasion of the osseous structures, with or without visible or palpable lymph node involvement, is not a rare occurrence. In a review of 107 cases of Hodgkin's disease, 82 of which were proved, the author found 8 cases in the latter group with roentgenologically demonstrable osseous changes. The skeletal lesions are of prime importance in those cases without evident superficial lymphadenopathy or splenic enlargement. Two such cases are reported. The roentgen findings and pathology are fully discussed.—*W. R. Brooksher.*

WEIDMAN, FRED D., and STOKES, JOSEPH, JR. Extensive xanthoma tuberosum in childhood due to infectious cirrhosis of the liver; development of xanthomatous changes in laparotomy and other scars. *Am. J. Dis. Child.*, May, 1937, *53*, 1230–1244.

Authors' summary. "A fatal case of jaundice and cutaneous xanthomatosis due to hypertrophic biliary cirrhosis in a child is described. The syndrome was differentiated from Christian–Schüller's disease and finally referred to a complex, xanthoma tuberosum which occurs in adults in connection with cirrhosis of the liver. Items which attracted special attention were the exceedingly high value for blood cholesterol

(1,199 mg. per hundred cubic centimeters), the development of xanthomatous changes in the scars of a laparotomy wound and of extracted teeth and the opportunity for histologic examination of the liver as a result of exploratory laparotomy.

"The occurrence of xanthomatous changes in the scars recalled attention to the fact that xanthomatous changes can involve a remarkably wide range of tissue forms besides connective tissue cells, e.g., epithelium, muscles, nerves, benign tumors, sarcoma and carcinoma. It is the duty of the physician to attempt to remove the disguise which the xanthomatous change may be placing over otherwise recognizable clinical complexes. The common ground occupied by Christian-Schüller's disease and multiple myeloma in particular is emphasized, and a plea is made for attention to the possible masquerade not only of reticulo-endothelial dyscrasia, so-called, but of such entities as tuberculosis and syphilis, under the guise of xanthoma."

Bakwin, Harry, and Krida, Arthur. Familial metaphysial dysplasia. *Am. J. Dis. Child.*, June, 1937, *53*, 1521–1527.

The authors report the occurrence in two siblings of an unusual generalized disease of the bones. The condition was symmetrical and was characterized by marked expansion of the metaphyses of the long bones (the distal halves of the femurs, the proximal and distal thirds of the tibias and fibulas, the proximal two-thirds of the humeri, the distal halves of the radii and the ulnas, the bones of the hands, the clavicles and probably also the ribs). The femurs and tibias were unusually long. The diseased portions of the bones showed cortical thinning, osteoporosis and a dense interlacing trabecular formation. The bony outlines and the articular surfaces were clean. There was a moderate osteomalacia, as indicated by the curving of the bones of the lower extremities. The spinal column was not involved. The occurrence of the disease in two siblings indicated that it was familial. The parents were normal and there was no history of bony deformity in the relatives. The condition manifested itself in early life, knock knee having been noticed in one of the patients at the age of eighteen months.

Ingalls reports the examination of a femur in a cadaver with a condition apparently identical with the disease in these patients. He found a short medullary cavity surrounded by unusually dense bone. In the involved portion of the bone the cortex was thin and the cancellous bone greatly increased in amount and somewhat irregularly distributed.

Clinically, the condition manifests itself by knock knee, weak foot, palpable expansion of the upper ends of the humeri and of the femurs and tibias about the knees, limitation of motion at the elbows and unusual length of the thighs and legs. There are no characteristic changes in the structure or chemistry of the blood. The process is apparently not progressive and does not appear to interfere with the general health.—*R. S. Bromer.*

Lowenburg, Harry, Sr., Shields, William P., and Turnoff, David. Scurvy with an unusual symptom. *Am. J. Dis. Child.*, July, 1937, *54*, 73–80.

A case of scurvy is reported in this paper in which the first clinical manifestation was the sudden appearance of a subaponeurotic hemorrhage involving the left posterolateral aspect of the head. There were no hemorrhagic manifestations in the gums, not even around the site of two erupted lower central incisor teeth. Except for some tenderness on pressure, clinical evidences of subperiosteal hematoma of the right femur were absent throughout the entire duration of the condition. Certainly there was no swelling. Although it must have occurred earlier, the hematoma was discovered by roentgenograms for the first time twenty-two days after the appearance of the subaponeurotic hematoma of the head.—*R. S. Bromer.*

Chown, B., and Lee, Margaret. Renal rickets and dwarfism as a pituitary disease. *Am. J. Dis. Child.*, Jan., 1937, *53*, 117–127.

The authors report the case of a female patient, aged eighteen and one-half, a dwarf, who showed reduced kidney function, polyuria, rickets-like changes in the long bones and delayed sexual development. She had a high normal vitamin D content of the blood and her bone lesions did not respond to the administration of vitamin D. She therefore was not suffering from avitaminotic rickets. Her blood calcium level was never found to be high, her urinary phosphorus was not increased and the shafts of her femurs did not show any increase in osteoclastic activity. These facts ruled out a

diagnosis of primary or secondary hyperparathyroidism. Also the clinical and other data obtained ruled out any continuing process of active destruction of the kidneys through increased mineral excretion. On the other hand, the blood calcium and phosphorus levels were pathologically labile, resembling those of rickets.

The authors tentatively accept three probable causes of renal rickets: (1) chronic nephritis, or malformation of the urinary tract, with renal failure and consequent simple rickets due to chemical imbalance, (2) primary or secondary hyperparathyroidism and (3) primary diencephalopituitary lesion. They lean to the latter as the common cause and suggest that the parathyroid enlargement in some cases is due to a primary pituitary lesion. They consider the condition in their patient was due to the third cause.—*R. S. Bromer.*

BERGSTRAND, HILDING. Four cases of Ewing sarcoma in ribs. *Am. J. Cancer*, May, 1936, *27*, 26–36.

The author calls attention to the 65 cases of Ewing's sarcoma described by Geschickter and Copeland. Only one of this group occurred in the ribs. Since this gives the impression that rib involvement was rare, 4 cases are reported in detail. Photographs, photomicrographs and roentgenograms are included.

These cases were very similar. The tumors originated from the posterior portion of one of the ribs, and grew like sponges into the pleural cavity, pushing the lifted periosteum and the pleura before them. The greatest length of the tumors was along the rib. The surface was coarsely lobate. The ribs presented a characteristic increase in density and volume, and spicules were formed. The latter occurred only on the inside of the rib, however, where the periosteum was elevated, but not on the outside, even though the tumor tissue grew around the rib. The loosening of the periosteum began at the point of attachment of the intercostal muscles.

In one case, treated by extirpation and roentgen rays, the patient is alive and well five years and a half after the operation, although metastases had occurred in the lungs two years after the operation. These disappeared under roentgen treatment.

The author believes that practically all Ewing sarcomas are localized to those parts of the skeleton in which ossification begins in the second month of fetal life. The first formation of the later ossifying blastema takes place at the same points. As the cells of Ewing's sarcoma are very similar to these blastema cells, the conclusion might tentatively be drawn that Ewing sarcomas are due to a disturbance in the formation of the skeleton at a very early stage of fetal life.—*E. E. Downs.*

REHBOCK, DONALD J., and HAUSER, HARRY. Liposarcoma of bone. *Am. J. Cancer*, May, 1936, *27*, 37–44.

Attention is called to the 3 cases first mentioned by Ewing and later reported by Stewart, of true primary liposarcoma of the bone. The diagnosis in these cases was made on circumstantial data.

Two cases are reported by the authors. In one, the primary tumor was in the femur with diffuse metastases in the lymph nodes and bone. The tumors were radiosensitive. The histological diagnosis was confirmed by Drs. Karsner, Ewing and Stewart. The second primary tumor was in the iliac bone. This case was without metastasis. The histological structure, in which there were embryonic fat cells with fat droplets in the cytoplasm as in the previous case, confirms the diagnosis of liposarcoma.—*E. E. Downs.*

FARIÑAS, P. L. Differential diagnosis of bone tumors of the extremities by arteriography. *Radiology*, July, 1937, *29*, 29–32.

Benign bone tumors may be differentiated from malignant by means of films taken immediately after the main artery supplying an extremity has been injected with 5 to 20 cc. of thorotrast. The vessels are displaced by benign growths but they remain regular in caliber and number. In the malignant tumors there are several large vascular pedicles supplying the tumors and there is noted, also, an irregular network of newly formed vessels of the same caliber running in all directions.—*J. H. Harris.*

ROENTGEN AND RADIUM THERAPY

KNIERER, W. Erfahrungen mit der Röntgen-Nahbestrahlung an Hautkarzinomen. (Experiences with close roentgen irradiation in carcinoma of the skin.) *Röntgenpraxis*, Jan., 1937, *9*, 27–30.

The following indications are employed. Absolutely operable cases are operated upon if

the patient consents. If not, they are treated with radiation at close distance, at 60 kv., 4 ma., and with 0.1 mm. Cu or 2 mm. Al filtration and 5 or 3 cm. focal skin distance. The relatively inoperable cancers are similarly treated, while the inoperable cases (large-sized, infiltrating tumors) are treated with deep therapy. The inoperable cases were at one time treated with radiation at close distance, but the results were not satisfactory and this type of treatment was given up. In treating skin cancers, single doses consisting of 300 r are given until erythema sets in. The total dose is always above 3,000 r. The highest total dose given in any of the cases was 5,200 r in twenty days.

Thirty-four cases of relatively inoperable skin cancers were treated by radiation at close distance. Primary results were obtained in all but one case, where a recurrence developed five months after the therapy. Seven absolutely inoperable cases were treated, and of these, primary results were obtained in only one case. The author concludes that deep-seated or widely infiltrated skin tumors should not be treated with radiation at close distance (Chaoul method).—*Eugene Freedman.*

Settle, Francis B. Cancer of the thyroid gland: a report of 10 cases. *California & Western Med.*, Sept., 1936, *45*, 247–251.

Ten cases of cancer of the thyroid, an incidence of 1.43 per cent among patients with some thyroid gland abnormality, are presented. Clinical or presumptive diagnoses were made in 7; in the remaining 3 microscopic study was necessary for diagnosis. The appearance of a rapidly growing tumor of the thyroid gland, a rapid increase in the size of the preëxisting tumor, or a rapid and repeated recurrence, is always suggestive of malignant change. Pain, difficulty in breathing and swallowing, huskiness of the voice and fixation of the tumor were common symptoms. There are no signs or symptoms by which early malignant change can be recognized. The positive clinical diagnosis can usually be made only after the cancer has perforated the capsule of the gland, involving the surrounding structures.

Five of the 10 cases had definite toxic symptoms. Metastasis occurred in all cases. Four cases were treated by surgery plus roentgen irradiation, surgery alone in 2, and no treatment was given to 3 cases. In one case a decompression operation was performed too late to be of benefit. Of the patients treated by combined surgery and irradiation, one is alive and well after ten years, one died after ten years of recurrent and rapid metastasis, one died at the end of thirty months of intercurrent illness with no evidence of recurrence or metastasis and one is alive and well at the end of two years with no evidence of recurrence.—*W. R. Brooksher.*

Nicholson, William P., and Berman, Maxwell D. Carcinoma of the breast: a study of the five-year end-results. *Ann. Surg.*, May, 1936, *103*, 683–693.

Report is made of a study of 261 cases of mammary carcinoma, of whom 74 were considered operable. The primary standard of operability of Lee was employed although the authors felt that some cases considered inoperable under this criterion may receive palliative relief from radical surgery. In over 75 per cent, a lump in the breast was the first abnormality noted, while 1 in every 12 cases presented pain as the first symptom. Painful swelling of the arm, pain in the lower back and certain other symptoms were observed to be definitely more unfavorable for prognosis than others. The peak in age incidence was in the years fifty-one to fifty-five, although 5 were in patients between twenty-six and thirty, and 8 were in the period thirty-one to thirty-five. Only 14 per cent occurred in single women, but the percentage of five-year cures was smaller. The primary operability appeared to increase with two or more pregnancies, suggesting that when the breast had performed its function there is less chance of a carcinoma being inoperable and a greater opportunity for a cure. It logically follows that with interruption of lactation, the breast should be thoroughly emptied with a breast pump. The clinical index of malignancy gives a reliable indication of the probable outcome and is more dependable than a pure histologic classification. Eighty-five per cent of the primary operable tumors were present in the central and upper portions of the breast. Of the 74 primarily operable cases, 46 per cent were dead at the end of five years, 4 per cent were living but with recurrences, 2.7 per cent died of other causes (proved autopsy) and 36.48 per cent were living without evidence

of disease. These cases were routinely irradiated preoperatively, followed in ten to fourteen days by radical mastectomy, then by one or more cycles of postoperative irradiation.—*W. R. Brooksher.*

SIMMONS, CHANNING C., TAYLOR, GRANTLEY W., and ADAMS, HERBERT D. Cancer of the breast: end-results, Massachusetts General Hospital, 1927, 1928, 1929. *New England J. Med.*, Sept. 17, 1936, *215*, 521–525.

One hundred fifty-nine cases of mammary cancer treated by radical operation during 1927, 1928 and 1929 are reviewed; 43.4 per cent were five-year survivals. Of 58 cases in which the disease was limited to the breast, 74.8 per cent were alive and without evidence of recurrence from five to seven years postoperatively, while of 101 cases with axillary gland involvement, 25 per cent were found to have a similar survival rate. Preoperative roentgen therapy was given in 42 cases, the dosage being 800 r to each of four fields. No improvement in the prognosis of these individuals as compared with those who received radical surgery only was noted.—*W. R. Brooksher.*

FÜSSL, E. Ein Beitrag zur Strahlentherapie der metastatischen Lungenkarzinose. (Observation on radiation therapy of metastatic carcinoma of the lungs.) *Röntgenpraxis*, March, 1937, *9*, 184–190.

Eight years before the onset of hemorrhage from the lung, associated with dyspnea and pain in the chest, an extirpation of a goitre was performed on the patient. On the second admission, eight years afterward, a chest examination showed the presence of scattered, nodular metastatic tumors. Two anterior and two posterior fields were utilized and each field received 600 r during one series. Only after the sixth series, given sixteen months after the first, were definite regressive changes noted in the lungs and marked improvement in the patient's general condition. Subsequently the patient remained symptom-free for about fifteen months. The patient died almost four and one-half years after radiation treatment was instituted. The autopsy showed metastatic tumors in the lungs and brain, without evidence of a primary tumor. All the tumors showed the histological picture of adenocarcinoma (primary site, thyroid?).

The author claims that certain forms of metastatic tumors in the lungs are radiosensitive and with the aid of continuous and properly administered radiation therapy, long remissions may be achieved.—*Eugene Freedman.*

MAYTUM, CHARLES K., and LEDDY, EUGENE T. Roentgen therapy for severe asthma. *Texas State J. Med.*, Jan., 1937, *32*, 610–612.

Report is made of the roentgen treatment of 23 patients who suffered from many attacks of asthma each day, from which only slight relief was obtained by usual therapy. Specific therapy had failed to give relief regardless of skin tests. Five per cent obtained marked and satisfactory relief that lasted many months; 35 per cent had relief from three weeks to two months; in the remaining cases the results were considered failures. Irradiation of the thorax through two paravertebral fields with 135 kv. (peak), 6 mm. Al, 40 cm., 5 ma., 2–26 minutes, usually completing the treatment in one session, is the favored technique. The treatment may, of course, be repeated several times at monthly intervals.—*W. R. Brooksher.*

SCHINDLER, RUDOLF. Chronic hypertrophic ulcerative gastritis treated by Coutard's method of roentgen therapy: case report with unusual course and result. *Am. J. Digest. Dis. & Nutrition*, Dec., 1936, *3*, 751–753.

In a patient observed over 12 years, fractionated roentgen therapy over forty-five days caused severe, acute, purulent gastritis with subsequent regeneration of an essentially normal mucous membrane. After one year, an atrophic gastritis appeared, its discomfort, however, not comparable with the former condition. Prolonged fractionated therapy should be restricted to those severe cases of hypertrophic ulcerative gastritis which have been observed gastropically over long periods and which fail to respond to the usual methods of therapy.—*W. R. Brooksher.*

PRATHER, GEO. C., and FRIEDMAN, HARRY F. The immediate effect of preoperative radiation in cortical tumors of the kidney. *New England J. Med.*, Oct. 8, 1936, *215*, 655–662.

About 5 per cent of malignant tumors of the renal cortex are too extensive when first seen to warrant surgical intervention. Another 12 to 26 per cent have been explored and found inoperable. The operative mortality where ne-

phrectomy has been performed is from 15 to 30 per cent. Thus, in from 35 to 60 per cent of these patients, no promising field of therapy has been made available. The authors report their results with protracted preoperative roentgen irradiation in 4 cases, in 3 of which the size of the tumor was reduced, permitting easier nephrectomy. One case of adrenal tumor, apparently not influenced by irradiation, is reported. Microscopic examination of the irradiated specimens shows necrosis as a constant finding. Irradiation does not cause a cure.—*W. R. Brooksher.*

Andrews, J. Robert, and Uhle, Charles A. W. Carcinoma of the urinary bladder; an evaluation of surgery and irradiation in the treatment of this disease. *Am. J. Cancer*, March, 1936, *26*, 507–511.

The series of 60 cases of carcinoma of the bladder was limited to those of proved histology, and in the end-results, those cases lost were considered dead. Under these standards, they found that only 1 out of 15, or 7 per cent, of the cases treated by surgery alone were living five years, while 27 receiving both roentgen irradiation and surgery showed 6, or 22 per cent, living at the end of five years. The authors advise pre- and postoperative deep roentgen therapy and, if radon is available, the implantation of gold seeds at the time of operation.—*J. S. Weber.*

Friedman, Asa B., and Seligman, Bernard. X-ray therapy in amenorrhea. *Radiology*, July, 1937, *29*, 99–103.

The authors recommend small doses of radiation to the ovary (not over 100 r) either alone or combined with similar therapy to the pituitary in treating cases of amenorrhea due to endocrinopathies. They report good results in 9 consecutive cases.—*J. H. Harris.*

Good, Frederick L. Menorrhagia and metrorrhagia of benign origin in women under forty-five years of age with a plea for more conservative treatment. *New England J. Med.*, Oct. 29, 1936, *215*, 805–808.

The author advocates diagnostic curettage or biopsy if there is the slightest suspicion of malignancy but never before all proper medical and endocrinologic studies have been performed. A conscientious decision should be made in each case as to whether irradiation or surgery is the preferable procedure. Certain cases of endometritis and fibroids and all cases of carcinoma of the cervix are better treated by irradiation. The preferable treatment for carcinoma of the fundus is irradiation followed by hysterectomy. Hysterectomy is advisable in fibroid tumors, excepting only the single very small ones; irradiation is advisable in not too marked cases of fibrosis.—*W. R. Brooksher.*

Richman, Samuel, and Selinsky, Herman. Schwannoma of the cauda equina: five-year result after roentgen therapy. *J. Mt. Sinai Hosp.*, Sept.–Oct., 1937, *4*, 134–137.

Report is made of a case of inoperable schwannoma (neuroglioma) of the cauda equina in which recovery has taken place after exploratory laminectomy and roentgen therapy. The patient has been comparatively free of symptoms for the past five years. Irradiation according to the Coutard method was administered; 3,380 r to the lumbar spine direct, 900 r to the right lumbar spine, and 800 r to the left lumbar spine, all measurements with back-scattering, a total of 5,080 r. A radiodermatitis with moist desquamation occurred ten days after the last treatment but completely healed within one week. The favorable result obtained is assumed to be due to: (1) the large total amount of radiation administered within a limited period of time (one month), and (2) the histologic character of the tumor which seemed to lend itself to beneficial response to irradiation, i.e., its gliogenous and vascular features.—*W. R. Brooksher.*

MISCELLANEOUS

Marshak, A., and Bollman, V. L. The absorption of x-rays by sperm and erythrocytes and its relation to the susceptibility of tissues to x-rays. *Am. J. Cancer*, March, 1936, *26*, 581–585.

It was found that the K alpha and K beta radiation of molybdenum was absorbed to a greater extent by sperm and nucleated erythrocytes than it was by tissues and plasma containing less nuclear material. The belief that the nuclei absorb more of the roentgen radiation fits with Desjardins' arrangement of tissues in the order of their susceptibility. The authors feel that the nuclear absorption is the main factor in the reaction of a tissue or tumor to roentgen rays and find that it is not impossible to assume that the chromatin is the sensitive portion.—*J. S. Weber.*

DES LIGNERIS, M., and GRASSET, E. Clinical experiments on the effect of African snake venoms on human cancer cases with or without concomitant deep therapy. *Am. J. Cancer*, March, 1936, *26*, 512–520.

A review of the literature dealing with the effects of venoms on cancers in both animals and humans reveals considerable controversy. The weight of evidence seems to be against any actual effect on the tumor growth. The one benefit most often reported is relief of pain and this was not observed by all investigators. In the animal experiments, the authors found occasional but inconstant deleterious effects produced by the venoms of African snakes on tumors but they thought that this was not due to any specific effect. Sixteen patients suffering from either carcinoma or sarcoma received injections of venoms from African snakes and many also received deep roentgen therapy. There was no sensitization of cancerous tissue to roentgen rays produced by the venom injections. There was an occasional temporary arrest or regression observed but the authors refused to accept this as a specific effect. The relief of pain was inconstant and rarely complete.—*J. S. Weber.*

WOODHOUSE, D. L. Chemotherapy investigations in cancer, with reference to the influence of some lead preparations on tar tumors in mice. *Am. J. Cancer*, June, 1936, *27*, 285–292.

The preparation of solutions of lead carbonate, lead oleate, lead sodium pyrophosphate, lead trypan blue, lead trypan red, lead pyrol blue, lead fluorescin, lead nucleotide, lead neosalvarsan, and lead alloys containing tin, antimony, cadmium or bismuth and their experimental utilization against tar epithelioma in mice are described. Although a few favorable reactions were observed, the author concludes that no claim of therapeutic value can be made. Recent contributions to the field are reviewed and found to be more or less conflicting.—*J. S. Weber.*

JORDAN, H. Roentgen analysis of the spine, with description of some new technical instruments. *Radiology*, 1937, *28*, 714–724.

A method of teleroentgenography of the spine is described. In this method films of the entire spine are made at 2 meters' distance. The tube is equipped with a special telescope and centering device. The importance of the examination of the articular facets is stressed. In films taken in this manner it is possible to identify a variation from normal as of recent or remote origin which information is of special value in medicolegal cases. The paper is largely technical and difficult to abstract; for this reason, it should be read by those interested.—*J. H. Harris.*

HUDSON, J. CRAMER. The dependence of x-ray erythema on wave length. *Radiology*, July, 1937, *29*, 95–98.

An analysis of data relative to the amount of radiation necessary to produce an erythema, obtained from calibrating a number of machines throughout New England was made. The author concludes that the variation of erythema doses in roentgens with effective wave length over the region from 200 kv. (peak), 0.5 mm. Cu filter to 100 kv. (peak), unfiltered is due chiefly to the difference in the absorption by the tissue.—*J. H. Harris.*

ECKERT, CLARENCE T., PROBSTEIN, J. G., and GALINSON, SIM. Radiation of the thyroid; an experimental study in radiosensitivity of the thyroid. *Radiology*, July, 1937, *29*, 40–44.

A report is given of experiments to demonstrate the effect of radiation upon the thyroid gland. Their findings confirm similar work previously reported which showed that radiation does not affect the normal thyroid tissue, but will definitely impair the ability of the thyroid parenchyma to reproduce as shown by the compensatory hypertrophy of the gland.—*J. H. Harris.*

SUBJECT INDEX TO VOLUME 39

(abs) = abstract (E) = editorial

Abdomen, acute, clinical roentgen examination of (abs), 844
healing of actinomycosis of, by fractionated roentgen therapy (abs), 669
value of preliminary film without opaque media in diagnosis of conditions of (abs), 843
Abscess, lung (abs), 149
solitary, of liver, diagnosis by thorotrast hepatosplenography (abs), 847
Accessory processes of spinal vertebrae, injuries to (abs), 490
Acetabulum, acute neisserian intrapelvic protrusion of (abs), 495
etiology of deep, and intrapelvic protrusion (abs), 494
Acetylcholine, effect of, on gastrointestinal motility (abs), 671
Actinomycosis of abdomen, healing of, by fractionated roentgen therapy (abs), 669
Adenocarcinoma of body of uterus, successful radiotherapy (abs), 154
Adnexa, inflammatory diseases of, roentgen treatment (abs), 155
Adrenals, changes observed in, following irradiation of thymus, 263
effect of roentgen irradiation of, on functional disturbances caused by trauma (abs), 320
tumors, differential diagnosis (abs), 469
tumors, perirenal air injection for demonstration of (abs), 469
Aeromammograms, 323
Ainhum (abs), 975
Air, substitution of, for lipiodol in roentgen visualization of tumors in spinal canal, 187
Alumin-ium and alumin-um (E), 290
Amenorrhea, roentgen therapy in (abs), 985
American Board of Radiology, diplomates of, 134
requirements and recommendations as to professional training, 142
American Radium Society, 830
Anastomoses, congenital abnormal arteriovenous, of extremities (abs), 660
Anemia, erythroblastic, treatment by total body irradiation (abs), 319
Aneurysm of right renal artery (abs), 463
ruptured popliteal, demonstration of, by thorium dioxide arteriography (abs), 660
traumatic, healing of, with radium therapy (abs), 665
Aneurysms around sinuses of Valsalva (abs), 465
multiple, of smaller branches of pulmonary artery (E), 289
thoracic aortic, developmental and life cycles of, 720
Angina pectoris, roentgen therapy in, 585
Anthracosilicosis and tuberculosis (abs), 150
Antrum, malignant tumor, treatment (abs), 667
Anus, carcinoma, combined roentgen and radium treatment (abs), 670
Aorta, coarctation of (abs), 841
thoracic aneurysms, developmental and life cycles, 720
Aortic arch, persistent right-sided, 713
Aortitis, early syphilitic, teleroentgenography in diagnosis of (abs), 840
roentgen treatment (abs), 315
Aqueous preparations to supplant oil in roentgenography, 564
Arteriography by thorium dioxide, demonstration of ruptured popliteal aneurysm by (abs), 660
diagnosis of congenital abnormal arteriovenous anastomoses of extremities by (abs), 660
differential diagnosis of bone tumors of extremities by (abs), 982
thorotrast, study of four cases of acquired arteriovenous fistula by (abs), 313
Artery, pulmonary, multiple aneurysms of smaller branches of (E), 289
Arthritis, and injuries to joints (abs), 495
Asbestosis, pulmonary, and carcinoma (abs), 150
Asthma, bronchial, roentgen studies of pathological physiology of, 353
severe, roentgen therapy (abs), 984
Atelectasis, pulmonary, roentgenology of horizontal linear areas of (abs), 842
Atlas, rare developmental abnormality of (abs), 489

Back, relation of pathologic changes of intervertebral discs to pain in lower part of (abs), 491
Back-scatter, study of, 799
Barium sulphate, colloidally suspended, examination of gastric mucosal relief by (abs), 845
Biliary passages, use of lipiodol in surgery of (abs), 152
system, extrahepatic, functional disorders of (abs), 846
Bismuth carbonate, roentgen study of excretion of, from lungs, 673
subnitrate, roentgen study of excretion of, from lungs, 675
Bladder, benign or malignant tumor, treatment (abs), 667
cancer, methods of applying radium element to, 820
carcinoma of, evaluation of surgery and irradiation in treatment (abs), 985
Blood cells, normal, effects of irradiation on, as determined by blood count, 235

count, effects of irradiation on normal blood cells as determined by, 235
qualitative changes in formed elements of, following therapeutic irradiation, 601
sugar in rabbits, effect of roentgen irradiation on (abs), 159
Boeck's sarcoid (E), 951
report of case and review of literature, 596
Bone, adult, influence of roentgen irradiation on phosphatase activity of callus of (abs), 157
atrophy, acute transverse (abs), 310
clinical application of serum phosphatase in diseases of (abs), 659
course of single myeloma of (abs), 312
human, diffraction studies on, 286
lesions, benign, showing spindle cell invasion of bone, 568
liposarcoma of (abs), 982
manifestations of Hodgkin's disease in (abs), 980
marrow, changes in rabbits produced by oral administration of radium sulphate (abs), 159
necrosis (abs), 467
roentgen evidence of metastatic malignancy in (abs), 660
tumors, difficulties in diagnosis (abs), 307
tumors of extremities, differential diagnosis by arteriography (abs), 982
tumors, roentgen therapy (abs), 316
young, effect of large doses of roentgen rays on growth of (abs), 157
Book Reviews
Elements of Nuclear Physics. By Franco Rasetti, 145
Diagnosis and Treatment of Malignant Tumors. Stanford University School of Medicine, 145
Röntgenganzaufnahmen des Menschen: Darstellung des normalen Skeletts seiner ererbten und erworbenen Veränderungen. Von Dr. Robert Janker, 145
Neurology. By Roy R. Grinker, 299
Die Zuverlässigkeit der Röntgendiagnostik—besonders Hinsichtlich des Wertes der Urographie—und die Prognose bei Nieren- und Harnleitersteinen. Von Helge B. Wulff, 299
Traité pratique de curiethérapie. Tome I. Généralités sur le radium et sur la curiethérapie du cancer. Par P. Degrais et A. Bellot, 300
Emanotherapy. By F. Howard Humphris and Leonard Williams, 300
The Collapse Therapy of Pulmonary Tuberculosis. By John Alexander, 472
Anales del centro de investigaciones tisiologicas. Edited by Professor Roque A. Izzo, 473
Principles of Roentgenological Interpretation. By L. R. Sante, 473
Radiokymographie du coeur et des vaisseaux. Par Emile Bordet et H. Fischgold, 473
Diagnosis and Non-operative Treatment of the Diseases of the Colon and Rectum. By Gottwald Schwarz, Jacques Goldberger, and Charles Crocker, 475
The Therapeutic Problem in Bowel Obstructions: A Physiological and Clinical Consideration. By Owen H. Wangensteen, 476
Chemistry of the Brain. By Irvine H. Page, 476
Allergy: Its Practical Application. By J. A. Rudolph, 477
The 1937 Year Book of Radiology. Edited by Charles A. Waters, Whitmer B. Firor, and Ira I. Kaplan, 651
Das Ventrikulogramm. II. Teil. Die Seitenventrikel. Von Erik Lysholm, Bertil Ebenius, and Hans Sahlstedt, 651
Die Hirnkammerformen bei Hirntumoren. Von Dr. Otto Dyes, 652
Artificial Fever Produced by Physical Means: Its Development and Application. By Clarence A. Neymann, 653
Fever Therapy. Abstracts and Discussions of Papers Presented at the First International Conference on Fever Therapy. Edited by the Members of the American Committee, 654
Theoretical Principles of Roentgen Therapy. Edited by Ernst A. Pohle, 831
Atlas of Skeletal Maturation. By T. Wingate Todd, 831
Medical Writing: Some Notes on Its Technic. By James H. Dempster, 832
Bowel, large, roentgen studies of, in infections by *Endamoeba histolytica* before, during and after treatment, 916
Brain, proved tumors of, ventricular changes caused by, 523
Breast, cancer, discussion of symposium on, 421
cancer, end-results (abs), 984
cancer, is roentgen irradiation of value in treatment of pulmonary metastasis from? 783
cancer, roentgen irradiation of ovaries as supplement to surgical and roentgen therapy of (abs), 670
cancer, simultaneous radium-roentgen treatment (abs), 152
cancer, surgery and irradiation in treatment of, 407
cancer, treatment (abs), 668
carcinoma (abs), 153
carcinoma, in young women (abs), 153
carcinoma, observations on, 397
carcinoma, rationale of artificial menopause in, 419
carcinoma, study of five-year end-results (abs), 983
carcinoma, treatment, 1
roentgen visualization and diagnosis of lesions of, by contrast media, 321
tumors, roentgen diagnosis (abs), 467

use of estrin in some conditions of, 92
Bronchi, study of, by bronchography in bronchial asthma, 353
Bronchiectasis, bilateral apical nontuberculous (abs), 149
coincident pulmonary tuberculosis and, in children (abs), 842
Bronchitis in children, roentgen therapy (abs), 319
Bronchography, post-mortem (abs), 152
Bronchomycoses, roentgenological recognition of, involving occupational risks, 19, 650
Bronchus, carcinoma of (abs), 842
carcinoma of, study of 57 cases (abs), 843

Calcifications, miliary, of spleen (abs), 847
Calcinosis universalis, 741
Calculi in seminal vesicles, 377
Caldwell Lecture, 1937, 1
Callus of adult bone, influence of roentgen irradiation on phosphatase activity of (abs), 157
Cancer, adaptation as a factor in cure of, by radiation, 165
chemotherapy investigations in (abs), 986
continuous and discontinuous roentgen therapy at long distances (abs), 664
experiments on effect of African snake venoms on, with or without deep therapy (abs), 986
Fichera's treatment of (abs), 317
heat as sensitizing agent in radiation therapy of (abs), 665
of bladder, methods of applying radium element to, 820
of body of uterus, roentgen therapy (abs), 154
of body of uterus, treatment (abs), 668
of breast, diagnosis by mammography, 336
of breast, discussion of symposium on, 421
of breast, end-results (abs), 984
of breast, is roentgen irradiation of value in treatment of pulmonary metastasis from? 783
of breast, roentgen irradiation of ovaries as supplement to surgical and roentgen therapy of (abs), 670
of breast, simultaneous radium-roentgen treatment (abs), 152
of breast, surgery and irradiation in treatment of, 407
of breast, treatment (abs), 668
of cervix, correlation of calculated tumor doses and five-year survivals in radiation therapy of, 861
of esophagus (abs), 153
of esophagus, treatment of (abs), 667
of lip, close roentgen irradiation of (abs), 318
of lip, methods of applying radium element to, 817
of lip, radium treatment (abs), 666
of prostate, radium and roentgen irradiation in, 75
of stomach, treatment (abs), 667
of thyroid (abs), 983
of thryoid in children (abs), 669
of tongue, radium treatment (abs), 666
of vagina, methods of applying radium element to, 820
palliation of, in gynecology, 866
plan of treatment of, with small quantities of radium (abs), 666
primary, of small intestine (abs), 488
relation of estrin to, 93
serum therapy in, 84
superficial, of wide and deep involvement, low voltage roentgen rays in (abs), 469
Carcinoma, bronchogenic, study of 57 cases (abs), 843
intraoral, cervical lymph nodes in, surgery or irradiation, 767
metastatic, in cervical lymph nodes, treatment (abs), 667
metastatic, of lungs, radiation therapy of (abs), 984
of anus, combined roentgen and radium treatment (abs), 670
of breast (abs), 153
of breast in young women (abs), 153
of breast, observations on, 397
of breast, rationale of artificial menopause in, 419
of breast, study of five-year end-results (abs), 983
of breast, treatment, 1
of bronchus (abs), 842
of cervix, intestinal injuries after radium and roentgen treatment of, 871
of cervix, methods of applying radium element to, 819
of cervix, treatment (abs), 668
of colon, treatment (abs), 667
of duodenum (abs), 488
of fundus uteri, changing phases in treatment of (abs), 468
of gallbladder (abs), 847
of layrnx, radiation treatment (abs), 667
of lung, radiation treatment, 427
of mouth and lip, irradiation of cervical glands in, 778
of ovary, results of treatment (abs), 661
of pancreas, roentgen diagnosis (abs), 846
of prostate, treatment (abs), 667
of rectum, combined roentgen and radium treatment (abs), 670
of rectum, technique of radium treatment (abs), 155
of rectum, treatment (abs), 667
of skin, close roentgen irradiation of (abs), 982
of stomach, clinical features of (abs), 844

of stomach, differentiation from syphilis by thorium dioxide injection (abs), 844
of urinary bladder, evaluation of surgery and irradiation in treatment of (abs), 985
of uterus, combination of radiotherapy with chemotherapy in (abs), 662
of uterus, irradiation in treatment of, 855
primary, of lungs, and asbestosis (abs), 150
primary, of lungs, roentgen therapy (abs), 669
roentgen therapy of (abs), 663
vertebral metastatic, symptomatology and therapy of (abs), 670
CARDIOVASCULAR SYSTEM, correlation between anatomy and roentgenology of (abs), 469
CARDITIS, roentgen treatment (abs), 315
CARPAL SCAPHOID, traumatic axial rotation by gear movement of, and trapezium, 945
CAUDA EQUINA, schwannoma of, five-year result after roentgen therapy (abs), 985
CAVITY, blocked pulmonary, anatomical, roentgenological and clinical study (abs), 151
CECUM, roentgen changes in, in infection with *Endamoeba histolytica*, 920
CHEMICAL specificity in growth and development (abs), 467
CHEMOTHERAPY, combination of, with radiotherapy in carcinoma of uterus (abs), 662
investigations in cancer (abs), 986
CHEST, simplification of roentgenography of, 970
CHILDREN, cancer of thyroid in (abs), 669
coincident pulmonary tuberculosis and bronchiectasis in (abs), 842
roentgen therapy of bronchitis in (abs), 319
CHOLECYSTOGRAPHY, newer concepts of diagnostic criteria based on 1,000 examinations by, 548
oral magnesium tetraiodophenolphthalein in, 373
CHRYSAROBIN, injury following application of, subsequent to roentgen treatment (abs), 665
CIRRHOSIS, infectious, of liver, extensive xanthoma tuberosum in childhood due to (abs), 980
of liver, roentgen studies (abs), 847
COARCTATION of aorta (abs), 841
COLON, carcinoma, treatment (abs), 667
diagnosis of diverticulitis and diverticulosis of (abs), 846
roentgen changes in, in infection with *Endamoeba histolytica*, 920
CONGENITAL abnormal arteriovenous anastomoses of extremities (abs), 660
COUTARD TECHNIQUE: See Roentgen irradiation and Roentgen therapy
CROSS-RADIATION, simultaneous, 274
CYST, benign bone, malignant degeneration of (abs), 496
CYSTS, acquired giant air, of lung (abs), 841
dermoid, unusual case of bilateral pulmonary apical, 205
of breast, diagnosis by mammography, 323, 331, 332
of lung (abs), 149 (abs), 841
DACTYLOLYSIS SPONTANEA: See AINHUM
DAVID ANDERSON-BERRY gold medal, notice concerning, 298
DEAFNESS, chronic catarrhal, treatment of selected cases (abs), 668
DENTAL PLATE, protective, to prevent undesirable radium reactions of structures adjacent to treated areas, 483
DIABETES, experimental, massive roentgen irradiation of hypophysis in, 95
DIAPHRAGMITIS, acute primary (abs), 152
DIFFRACTION STUDIES of effect of sodium fluoride and parathormone upon incisors and tibiae of rats, 103
on human bone, 286
x-ray, of globular proteins (abs), 672
DIPLOMATES of American Board of Radiology, 134
DIVERTICULITIS of colon, diagnosis of (abs), 846
DIVERTICULOSIS of colon, diagnosis of (abs), 846
DOGS, production of nephritis in, by roentgen rays (abs), 160
DOSAGE chart for interstitial radium element needles, 590
Dracunulus medinensis, 210
Drosophila eggs, experiments on, with neutrons and roentgen rays, 613
DUODENUM, neoplasms involving (abs), 488
DUST, industrial pulmonary disease due to inhalation of (abs), 149; (abs), 150
DUSTS, roentgenographic study of excretion of, from lungs, 673
DWARFISM and renal rickets as pituitary disease (abs), 981

EASTERN RADIOLOGISTS, Conference of, 144
Conference of, report of meeting, 463
EASTMOND, CHARLES, 1879–1937, obituary (E), 130
portrait of, 130
EDITORIALS
Lord Rutherford of Nelson, 1871–1937, 128
Charles Eastmond, 1879–1937, 130
Multiple aneurysms of the smaller branches of the pulmonary artery, 289
Alumin-ium and alumin-um, 290
Wilbur S. Werner, 1895–1937, 291
Pulmonary changes in undulant fever, 459
Fractures of the skull, 642
Sanford Martin Withers, 1891–1938, 823
Boeck's sarcoid, 951
EDUCATION, radiological, in England, 381
EFFECT of African snake venoms on human cancer, with or without deep therapy (abs), 986
of irradiation on normal blood cells as determined by blood count, 235
of irradiation of thyroid gland on ovarian function (abs), 157
of large doses of x-rays on growth of young bones (abs), 157
of roentgen irradiation on blood sugar in rabbits (abs), 159

of roentgen irradiation on rate of healing of fractures and phosphatase activity of callus of adult bone (abs), 157
of sugar and insulin injection on roentgen therapy of malignant tumors (abs), 158
Egg albumin, x-ray diffraction studies of (abs), 672
Electric arc welders, roentgen appearances of lungs of (abs), 485
Encephalography, experimental, with anesthetic gases (abs), 158
study of post-traumatic sequelae of head injuries by (abs), 839
Endamoeba histolytica, roentgen studies of large bowel in infections by, before, during and after treatment, 916
England, radiological education in, 381
Enteric coatings, 450
Enteritis, regional (nonspecific) (abs), 305
Epilepsy, genuine, determining factors in pathogenesis of, as shown by roentgen methods (abs), 485
roentgen study of skull in, 534
Epiphyses, end-results of injuries to (abs), 489
multiple anomalies of, in hands of patient with Legg-Perthes' disease (abs), 489
Epiphysiolysis of upper femur (abs), 309
or epiphysial coxa anteverta (abs), 977
Epithelioma of penis, treatment of (abs), 668
of skin, radium treatment (abs), 666
Erysipelas, roentgen treatment (abs), 317
Erythema, roentgen-ray, dependence of, on wave length (abs), 986
Erythrocytes, absorption of roentgen rays by (abs), 985
Esophagus, cancer of (abs), 153
cancer, treatment (abs), 667
congenitally short (abs), 466
displacement of, by cardiac lesions other than mitral stenosis (abs), 840
primary leiomyosarcoma of upper third of (abs), 840
Estrin, therapeutic uses of, 90
Excretion of dusts from lungs, roentgenographic study, 673
Extrapolation chamber, Failla's, 800
Extremities, clinical aspects of fibrosarcoma of soft tissues of (abs), 314
congenital abnormal arteriovenous anastomoses of (abs), 660
differential diagnosis of bone tumors of, by arteriography (abs), 982
simplification of roentgenography of, 969

Face, gangrene of, produced by lymphosarcoma (abs), 839
Fat, effect of, introduced into jejunum by fistula on motility and emptying time of stomach (abs), 672
Female, roentgen diagnosis of urological and gynecological diseases of (abs), 306
Femur, neck of, inflammatory localized lesions of juxta-epiphyseal zone of (abs), 308
roentgenography of neck of, 834
upper, epiphysiolysis of (abs), 309
Fibrin bodies in pleural space in case of artificial pneumothorax (abs), 150
Fibroadenoma of breast, diagnosis by mammography, 336
Fibromyoma, calcified, of uterus simulating large vesical calculus (abs), 848
Fibrosarcoma of soft parts (abs), 666
of soft tissues of extremities, clinical aspects (abs), 314
Fichera's cancer treatment, experience with (abs), 317
Fistula, acquired arteriovenous, study of, by thorotrast arteriography (abs), 313
between pleura and stomach (abs), 843
Fractures, influence of roentgen irradiation on rate of healing of (abs), 157
isolated, of vertebral arch, 43
non-union, probable causes (abs), 310
of skull (E), 642
Functional disorders of extrahepatic biliary system (abs), 846
disturbances caused by trauma, effect of roentgen irradiation of sympathetic and suprarenals on (abs), 320

Galactoceles, diagnosis by mammography, 333
Gallbladder, carcinoma of (abs), 847
historical review of roentgen studies of, 548
Ganglioneuromas, intrathoracic (abs), 465
Gangrene of face produced by lymphosarcoma (abs), 839
Gas gangrene, roentgen rays as aid in treatment of (abs), 318
Gases, anesthetic, experimental encephalography with (abs), 158
Gastritis, allergic, roentgen observation and visualization of (abs), 845
chronic hypertrophic ulcerative, treated by Coutard's method of roentgen therapy (abs), 984
Gastrointestinal tract, effect of acetylcholine and physostigmine on motility of (abs), 671
effect of posterior pituitary extracts on motility of (abs), 672
motility of, 64
protection during roentgenoscopy of, 480
simplification of roentgenography of, 969
studies in motility of (abs), 671
Georgia Radiological Society, 144
German Roentgenologists and Radiologists in Republic of Czechoslovakia, Association of, report of meeting, 646
Goiter, regional distribution of, in United States, 910
Gonads, changes observed in, following irradiation of thymus, 263

GRAIN WORKERS, mycosis of, 23
GRANULOMAS, amebic, 921
GROWTH, body, changes observed in, follwing irradiation of thymus, 263
chemical specificity in (abs), 467
GUINEA-WORM, calcified, 210
GYNECOLOGICAL DISEASES in female, roentgen diagnosis (abs), 306
GYNECOLOGY, palliation of cancer in, 866

HANDS, multiple epiphyseal anomalies in, of patient with Legg-Perthes' disease (abs), 489
HAYWORKERS, mycosis of, 20
HEAD, roentgen findings of post-traumatic sequelae of injuries to (abs), 839
HEART, displacement of esophagus by lesions of, other than mitral stenosis (abs), 840
extreme enlargement of (abs), 840
roentgen kymography of conditions of (abs), 486
HEAT as sensitizing agent in radiation therapy of neoplastic diseases (abs), 665
HEDBLOM'S SYNDROME (abs), 152
HEMANGIO-ENDOTHELIOMA, sensitiveness of, to irradiation (abs), 155
HEMANGIOMA, treatment of (abs), 470
weak radium therapy of (abs), 664
HEMATOMA, chronic subdural (abs), 485
HEPATODIAPHRAGMATIC INTERPOSITION of large intestine, roentgen diagnosis, 928
HEPATOSPLENOGRAPHY, thorotrast, diagnosis of solitary liver abscess by (abs), 847
with stabilized thorium dioxide sol (abs), 487
HERNIA, mediastinal, in absence of pneumothorax, 687
HERPES SIMPLEX, radiation treatment, 393
HEUBLEIN'S METHOD, modification of (abs), 664
HICKEY MEMORIAL LECTURE, notice concerning, 471
HIPS, lateral views of, 964
HISTORICAL review of roentgen studies of gallbladder, 548
HODGKIN'S DISEASE with bone manifestations (abs), 980
HYDATID DISEASE of kidney (abs), 306
HYPERCALCEMIA, effects of, on joints (abs), 311
HYPERPARATHYROIDISM, operation for, followed by hypoparathyroidism (abs), 660
HYPOPARATHYROIDISM following operation for hyperparathyroidism due to adenoma tolerance for parathyroid extract (abs), 660
HYPERTROPHY, benign, of prostate, radium and roentgen irradiation in, 75
HYPOPHYSIS, massive roentgen irradiation of, in experimental diabetes, 95
HYPOPROTEINEMIA, effect of, on small intestine (abs), 466
HYSTEROGRAPHY as aid in diagnosis of abdominal pregnancy (abs), 488

ILEITIS, regional (abs), 488
ILLINOIS RADIOLOGICAL SOCIETY, 650
INDUSTRIAL pulmonary disease due to inhalation of dust (abs), 149; (abs), 150
INFANTS, osteomyelitis of (abs), 495
INFECTIONS of nasal accessory sinuses, roentgen therapy of, 578
INFLAMMATORY diseases of adnexa, roentgen treatment (abs), 155
lesions of juxta-epiphyseal zone of neck of femur (abs), 308
INJURIES following application of chrysarobin after roentgen irradiation (abs), 665
late, resulting from irradiation and those appearing post-traumatically (abs), 665
of skin caused by irradiation, successful treatment of (abs), 318
INK, indelible, for skin, 144
INSULIN, influence of injection of, and sugar, on roentgen therapy of malignant tumors (abs), 158
INTERNATIONAL CANCER CONGRESS, 471
INTERVERTEBRAL DISCS, lumbosacral, acute traumatic destruction of (abs), 492
lumbosacral, chronic traumatic (postural) destruction of (abs), 493
relation of pathologic changes of, to pain in lower part of back (abs), 491
root pain resulting from intraspinal protrusion of (abs), 975
"sciatica" caused by lesions of (abs), 492
INTESTINE, injuries to, after radium and roentgen treatment of carcinoma of cervix, 871
large, roentgen diagnosis of hepatodiaphragmatic interposition of, 928
small, effect of hypoproteinemia on (abs), 466
small, primary malignancy of (abs), 488
small, roentgen diagnosis of lesions of (abs), 845
small, ulceration of, following irradiation of pelvis, 895
INTRAPELVIC PROTRUSION, acute neisserian, of acetabulum (Otto pelvis) (abs), 495
of acetabulum (abs), 494
IODIZED oil, aqueous preparations to supplant, in roentgenography, 564
salt, incidence of enlarged thymus following prenatal use of, 908
IRRADIATION, effects of, on normal blood cells as determined by blood count, 235
late injuries resulting from (abs), 665
sensitiveness of hemangio-endothelioma to (abs), 155
therapeutic, qualitative changes in formed elements of blood following, 601

JEJUNUM, effect of fat introduced into, by fistula on motility and emptying time of stomach (abs), 672
JOINT changes resulting from patellar displacement and their relation to degenerative joint disease (abs), 980

Joints, effects of hypercalcemia on (abs), 311
injuries to, and arthritis (abs), 495
roentgenography of tuberculosis of (abs), 979

Kidney, congenital solitary, rupture of, 731
cortical tumors of, immediate effect of preoperative radiation (abs), 984
hypoplastic, 732
Kidneys, hydatid disease of (abs), 306
rhythmic cyclic alternating activity of, 379
tumors, pyelogram in (abs), 848
Kohler's disease of tarsal scaphoid (abs), 978
Kümmell's disease (abs), 308
Kymograph, roentgen, construction of an inexpensive, 959
Kymography, roentgen, studies of cardiac conditions by (abs), 486
Kyphosis, juvenile, relation to spinal deformity following tetanus (abs), 491

Laminagraph, and its variations, 497
body section roentgenography with, 514
Larynx, carcinoma, radiation treatment (abs), 667
malignant tumors, present standpoint in treatment of (abs), 669
Lead glass, powdered, roentgen study of excretion of, from lungs, 674
influence of some preparations of, on tar tumors in mice (abs), 986
perforation and reciprocal, combined, for radiation therapy, 303
Legg-Perthes' disease, multiple epiphyseal anomalies in hands of patient with (abs), 489
Leiomyosarcoma, primary, of upper third of esophagus (abs), 840
Leukocytosis in lymphoblastoma, reaction to roentgen therapy, 747
Leukopenia in lymphoblastoma, reaction to roentgen therapy, 747
Lip, cancer, close roentgen irradiation of (abs), 318
cancer, methods of applying radium element to, 817
cancer, radium treatment (abs), 666
carcinoma, irradiation of cervical glands in, 778
Lipiodol for diagnosis of root pain resulting from intraspinal protrusion of intervertebral discs (abs), 976
use of, in surgery of biliary passages (abs), 152
Lipoma of breast, diagnosis by mammography, 335
Liposarcoma of bone (abs), 982
Liver, cirrhosis, roentgen studies (abs), 847
infectious cirrhosis of, extensive xanthoma tuberosum in childhood due to (abs), 980
serum phosphatase as aid in diagnosis of metastatic malignancy in (abs), 471
solitary abscess, diagnosis by thorotrast hepatosplenography (abs), 847
Lungs, abscess (abs), 149
acquired giant air cysts of (abs), 841
asbestosis of, and carcinoma (abs), 150
atelectasis, roentgenology of horizontal linear areas of (abs), 842
block cavities, anatomical, roentgenological and clinical study (abs), 151
carcinoma, radiation treatment, 427
changes in, in undulant fever (E), 459
cystic disease of (abs), 149; (abs), 841
distribution and prognosis of tuberculous and non-tuberculous lesions of (abs), 148
expiratory roentgenograms for pulmonary apical detail, 363
industrial disease of, due to inhalation of dust (abs), 149; (abs), 150
metastasis to, from mammary cancer, is roentgen irradiation of value in? 783
metastatic carcinoma of, radiation therapy (abs), 984
of electric arc welders, roentgen appearances (abs), 485
pleuropulmonitis following irradiation, 387
primary carcinoma, roentgen therapy (abs), 669
pulmonary tuberculosis of lower lobe (abs), 148
roentgenographic study of excretion of dusts from, 673
syphilis of (abs), 486
unusual case of bilateral pulmonary apical dermoid cysts, 205
Lymph nodes, cervical, in intraoral carcinoma, surgery or irradiation, 767
cervical, irradiation of, in carcinoma of mouth and lip, 778
cervical, metastatic carcinoma in, treatment (abs), 667
changes in, in rabbits, produced by oral administration of radium sulphate (abs), 159
metastatic, methods of applying radium element to, 819
Lymphadenoma, roentgen treatment, 261
Lymphoblastoma, leukopenia and leukocytosis in, their reaction to roentgen therapy, 747
Lymphosarcoma, gangrene of face produced by (abs), 839
of mediastinum with metastases to skeleton (abs), 975
of pharynx, protracted roentgen therapy of, 792

Mammography, 322
Mastitis, chronic cystic, use of estrin in, 92
following use of thorium dioxide (abs), 839
Mastoiditis, roentgenologic aspects of, 193
Mastoids, submentovertex view as aid in roentgenography of, 59
Mediastinum, hernia of, in absence of pneumothorax, 687
lymphosarcoma of, with metastases to skeleton (abs), 975
Medicine, unity of, 161
Megacolon, hypotonic, treatment of, by pancreatic tissue extract (abs), 846

roentgen studies of, treated by sympathectomy, 228
sigmoid, roentgen diagnosis of volvulus of, 925
MELANOMA, malignant, treatment of (abs), 666
MELORHEOSTOSIS LÉRI (abs), 312
MENINGIOMAS, from roentgen viewpoint, 698
MENOPAUSE, artificial, rationale of, in carcinoma of breast, 419
metrorrhagias after, roentgen therapy (abs), 154
use of estrin in symptoms connected with, 91
MENORRHAGIA of benign origin in women under forty-five years of age (abs), 985
MENSTRUATION, use of estrin in disorders of, 93
MESOTHORIUM NEEDLES, sterilization of, for surgical purposes (abs), 159
METACARPAL, first, subluxation and foreshortening of, 945
METAPHYSIAL DYSPLASIA, familial (abs), 981
METASTASIS, carcinoma, to lungs, radiation therapy (abs), 984
in bone, roentgen evidence of (abs), 660
pulmonary, is roentgen irradiation of value in treatment of, from mammary cancer? 783
to cervical lymph nodes from intraoral cancer, surgery or irradiation, 773
to skeleton from lymphosarcoma of mediastinum (abs), 975
METRORRHAGIA after menopause, roentgen therapy (abs), 154
of benign origin in women under forty-five years of age (abs), 985
MIDWESTERN RADIOLOGISTS, Clinical Conference of, 144
program of, 829
MOUTH, carcinoma, irradiation of cervical glands in, 778
lesions, method of applying radium element to, 818
MUCOSA, gastric, relief of (abs), 845
MYCOSIS of grain workers, 23
of hayworkers, 20
of soil workers, 24
MYELOGRAPHY, air, 187
with thorotrast and subsequent removal by forced drainage, 727
MYELOMA, endothelial (abs), 311
multiple (abs), 980
plasma cell, 344
single, of bone, course of (abs), 312
MYOMA of uterus, relation of presenting symptoms to selection of method of treatment in, 849
MYOSITIS OSSIFICANS progressiva (abs), 658
traumatica (abs), 975

NEPHRITIS, production of, in dogs, by roentgen rays (abs), 160
NEUTRONS, differences in relative action of, and roentgen rays on closely related tissue, 613
NOSE, recurrent polypi of, radium treatment (abs), 315

OBSTETRICS, roentgenography in (abs), 848
OCCIPITAL BONE, correlation between skull markings and roentgenograms of (abs), 485
OCCUPATIONAL risks, roentgenological recognition of certain bronchomycoses involving, 19
OS ACROMIALE (abs), 978
OSTEOARTHROPATHY, generalized hypertrophic pulmonary (abs), 312
OSTEOCHONDRODYSTROPHY, generalized, eccentrochondroplastic form (abs), 658
OSTEOCHONDROSIS DEFORMANS TIBIAE (abs), 978
OSTEOGENESIS IMPERFECTA (abs), 659
OSTEOMYELITIS of infants (abs), 495
of vertebrae, roentgen diagnosis, 52
OSTEOPHYTOSIS, idiopathic familial generalized, 216
OTTO PELVIS: see Intrapelvic protrusion
OVARIAN deficiency, acquired, use of estrin in, 91
function, effect of irradiation of thryoid gland on (abs), 157
OVARIES, irradiation of (abs), 670
primary malignant tumors (abs), 315
roentgen irradiation of, as supplement to surgical and roentgen therapy for mammary cancer (abs), 670
OVARY, carcinoma, results of treatment (abs), 661
malignant tumor, treatment (abs), 668
OXYGEN saturation test, diagnosis of congenital abnormal arteriovenous anastomoses of extremities by (abs), 660

PANCREAS, carcinoma, roentgen diagnosis (abs), 846
PANCREATIC tissue extract, treatment of hypotonic megacolon by (abs), 846
PAPILLOMA, of breast, diagnosis by mammography, 330
PARATHORMONE, diffraction studies of effect of, on incisors and tibiae of rats, 103
PARATHYROID GLAND, tumors of, diagnosis and treatment (abs), 464
PARIETAL foramina, enlarged (abs), 464
PAROTID GLAND, tumor, treatment (abs), 667
PAROTITIS, acute postoperative, roentgen therapy of (abs), 319
acute secondary (abs), 467
PATELLA, joint changes resulting from displacement of, and their relation to degenerative joint disease (abs), 980
PELVIMETRY, nine methods of (abs), 848
PELVIS, ulceration of small intestine following irradiation of, 895
PENIS, epithelioma, treatment (abs), 668
plastic induration of, weak roentgen therapy of (abs), 664
PENTOBARBITAL sodium, use of, for roentgen nausea and vomiting (abs), 665
PERTHES' DISEASE: see also Legg-Perthes' disease
of traumatic origin, histopathologic study of case of (abs), 494
PFAHLER, GEORGE E., Caldwell lecturer, 1937, portrait opposite page 1

Pharyngitis, chronic, roentgen therapy in (abs), 465
Pharynx, lymphosarcoma, protracted roentgen therapy of, 792
malignant tumors, present standpoint in treatment of (abs), 669
Phlebectasia, diffuse genuine (abs), 660
Phosphatase activity of callus of adult bone, influence of roentgen irradiation on (abs), 157
serum, clinical application in diseases of bone (abs), 659
Physiology, pathological, of bronchial asthma, roentgen studies of, 353
Physostigmine, effect of, on gastrointestinal motility (abs), 671
Phytobezoar, 67
Pineal body, comparison of methods used in orientation of, 899
roentgen study of orientation of, 899
Pituitary, changes observed in, following irradiation of thymus, 263
extracts, posterior, effect of, on motility of gastrointestinal tract (abs), 672
renal rickets and dwarfism as disease of (abs), 981
use of estrin in disorders of, 93
Planigraphy, applications and implications of principles of, 497
by means of laminagraph, 514
Plasma cell myeloma, 344
Pleura and stomach, fistula between (abs), 843
Pleural effusion, bilateral, treatment of (abs), 464
space, fibrin bodies in, in case of artificial pneumothorax (abs), 150
Pleuropulmonitis following irradiation, 387
Pneumatocele, pulmonary (abs), 841
Pneumonia, lobar and bronchial, roentgen treatment of, in adults and children (abs), 470
maxillary sinusitis associated with, as seen in winter of 1936, 202
Pneumonoconiosis, simultaneous bilateral spontaneous pneumothorax complicating (abs), 151
Pneumoperitoneum, correct diagnosis of confining pelvic conditions by (abs), 843
in intestinal tuberculosis (abs), 305
Pneumothorax, artificial, fibrin bodies in pleural space in case of (abs), 150
artificial, indications for terminating (abs), 151
bilateral artificial in treatment of pulmonary tuberculosis (abs), 150
bilateral simultaneous artificial, in treatment of pulmonary tuberculosis (abs), 151
bilateral spontaneous idiopathic, in apparently healthy individuals (abs), 486
mediastinal hernia in absence of, 687
simultaneous bilateral spontaneous, complicating pneumonoconiosis (abs), 151
Polycythemia vera, treatment of, by total body irradiation (abs), 319
Polypi, recurrent nasal, radium treatment (abs), 315
Pregnancy, abdominal, hysterography as aid in diagnosis of (abs), 488
Proctitis, factitial (radium) (abs), 662
Prostate, carcinoma, treatment (abs), 667
use of radium and roentgen irradiation in benign hypertrophy and cancer of, 75
Protection during gastrointestinal roentgenoscopy, 480
million volt roentgen-ray, 972
roentgen-ray and electrical, with reference to roentgen tubes, 278
Protective dental plate to prevent undesirable radium reactions of structures adjacent to treated area, 483
Proteins, globular, x-ray diffraction studies of (abs), 672
Protrusion, intraspinal, of intervertebral discs, root pain resulting from (abs), 975
Pubic bones, their symphysis (abs), 494
Pylorospasm, allergic, roentgen observation and visualization of (abs), 845

Rabbits, bone marrow and lymph node changes in, produced by oral administration of radium sulphate (abs), 159
usefulness of, for blood sugar experiments (abs), 159
Radiation, adaptation as factor in cure of cancer by, 165
intensity, secondary, as function of certain geometrical variables, 628
method of spacing, in treatment of tumors (abs), 314
spatial distribution of, from supervoltage roentgen tube, 634
therapy, combined lead perforator and reciprocal for, 303
therapy of neoplastic diseases, heat as sensitizing agent in (abs), 665
Radiological education in England, 381
units, recommendations of International Committee for, 295
Radiologist, reminiscences of a, 169
Radiology, tribute to martyrs of, 830
undergraduate study of, at University of Oregon Department of Medicine, 649
Radio-sodium, intravenous and intraduodenal administration (abs), 487
Radiotherapy, experimental observations on rationale of (abs), 662
Radium element, methods of applying, in form of needles and tubes, 816
element needles, interestitial, dosage chart for, 590
emanations, permeability of human skin to, in air bath (abs), 159
needles, sterilization of, for surgical purposes (abs), 159

plan of treatment of cancer, with small quantities of (abs), 666
poisoning, experimental (abs), 159
protective dental plate to prevent undesirable reactions from, of structures adjacent to treated area, 483
sulphate, bone marrow and lymph node changes in rabbits, produced by oral administration of (abs), 159
therapy, weak (abs), 664
RADON, results of treatment with small doses of (abs), 663
RECTOSIGMOID ulcer, following roentgen and radium treatment of carcinoma of cervix, 879
RECTUM, carcinoma, combined roentgen and radium treatment (abs), 670
carcinoma, technique of radium treatment (abs), 155
carcinoma, treatment (abs), 667
ulcer of, following roentgen and radium treatment of carcinoma of cervix, 878
RESOLUTION, process of, in pulmonary tuberculosis (abs), 148
RHYTHM of kidneys and other organs, 379
RIBS, Ewing sarcoma in (abs), 982
RICKETS, renal, and dwarfism as pituitary disease (abs), 981
ROENTGEN films, reinforcement for markers for, 655
irradiation by technique of simultaneous cross-radiation, 274
irradiation, close, of cancer of lip (abs), 318
irradiation, close, of carcinoma of skin (abs), 982
irradiation, effect of, of thyroid on ovarian function (abs), 157
irradiation, effect of, on blood sugar in rabbits (abs), 159
irradiation, effect of, on rate of healing of fractures and phosphatase activity of callus of adult bone (abs), 157
irradiation, fractionated, healing of actinomycosis of abdomen by (abs), 669
irradiation, injury following, due to application of crysarobin subsequent to treatment (abs), 665
irradiation, massive, of hypophysis, in experimental diabetes, 95
irradiation, pleuropulmonitis following, 387
irradiation, protracted fractional (abs), 663
irradiation, successful treatment of injuries of skin caused by (abs), 318
irradiation, total body, in polycythemia vera and erythroblastic anemia (abs), 319
-ray diffraction, studies of globular proteins (abs), 672
-ray protections, million volt, 972
rays, absorption of, by sperm and erythrocytes (abs), 985
rays, differences in relative action of neutrons and, on closely related tissues, 613
rays, effect of large doses of, on growth of young bones (abs), 157
rays, production of nephritis in dogs by (abs), 160
sickness, mode of origin and treatment of (abs), 320
sickness, pentobarbital for (abs), 665
therapy, Coutard's method, chronic hypertrophic ulcerative gastritis treated by (abs), 984
therapy of cancer, modification of Heublein's method (abs), 664
therapy, protracted, of pharyngeal lymphosarcoma, 792
tube, supervoltage, spatial distribution of radiation from, 634
tubes, roentgen-ray and electrical protection of, 278
ROENTGENOGRAM, preliminary, value of, without opaque media in diagnosis of abdominal conditions (abs), 843
ROENTGENOGRAMS, depth effects in, 439
expiratory, for pulmonary apical detail, 363
new method of looking at, to improve effect (abs), 159
ROENTGENOGRAPHY, aqueous preparations to supplant oil in, 564
body section, with laminagraph, 514
in obstretrics (abs), 848
of femoral neck, 834
of mastoid, submentovertex view as aid in, 59
ROENTGENOLOGIC appearances of normal skull, 32
ROENTGENOLOGICAL recognition of certain bronchomycoses involving occupational risks, 19
ROENTGENOLOGY, diagnostic, suggestions for simplifying technique in, 967
ROENTGENOSCOPY, gastrointestinal, protection during, 480
localization of tuberculous lesions of lung for best roentgenographic reproduction, 368
RUPTURE of congenital solitary kidney, 731
RUTHERFORD, LORD, OF NELSON, 1871–1937, obituary (E), 128

SALT, iodized, incidence of enlarged thymus following prenatal use of, 908
SARCOMA, Ewing's (abs), 311
Ewing's, of ribs (abs), 982
neurogenic, treatment of (abs), 666
of stomach (abs), 487
SCHWANNOMA of cauda equina, five-year result after roentgen therapy (abs), 985
"SCIATICA" caused by intervertebral disc lesions (abs), 492
SCURVY, with an unusual symptom (abs), 981
SEMINAL VESICLES, calculi in, 377
SEMINOMA, radiotherapy of (abs), 661
SERUM phosphatase, clinical application in diseases of bone (abs), 659
therapy in cancer, 84

Sigmoid megacolon, volvulus of, roentgen diagnosis, 925
Silicosis: see also Anthracosilicosis
differential diagnostic problems (abs), 149
Sinuses, cranial venous (abs), 485
nasal accessory, roentgen therapy of infections of, 578
of Valsalva, aneurysms around (abs), 465
simplification of roentgenography of, 970
Sinusitis, maxillary, associated with pneumonia as seen in winter of 1936, 202
subacute and chronic, treatment by roentgen radiation, 271
Skeleton, metastases to, from lymphosarcoma of mediastinum (abs), 975
unusual cartilaginous tumor formation of (abs), 496
Skin, carcinoma, close roentgen irradiation of (abs), 982
epithelioma of, radium treatment (abs), 666
human, permeability of, to radium emanations in air bath (abs), 159
indelible ink for, 144
injuries of, caused by irradiation, successful treatment (abs), 318
lesions of, method of applying radium element to, 816
Skull, correlation between markings of, and roentgenograms of occipital (abs), 485
fractures of (E), 642
normal, from roentgenologic viewpoint, 32
roentgen study of, in epilepsy, 534
Sodium fluoride, diffraction studies of effect of, on incisors and tibiae of rats, 103
Soft tissues, fibrosarcoma of (abs), 666
of extremities, clinical aspects of fibrosarcoma of (abs), 314
Soil workers, mycosis of, 24
Sperm, absorption of roentgen rays by (abs), 985
Spina bifida occulta, clinical findings in, 941
roentgen aspects of, 937
Spinal canal, substitution of air for lipiodol in roentgen visualization of tumors in, 187
fluid, changes in spina bifida occulta, 940
Spindle cell invasion of bone in benign bone lesions, 568
Spine, cervical, localized hypertrophic changes in, with compression of spinal cord or its roots (abs), 489
deformity of, following tetanus and its relation to juvenile kyphosis (abs), 491
injuries to accessory processes of spinal vertebrae (abs), 490
isolated fractures of vertebral arch, 43
lower, roentgen interpretation of injuries of (abs), 466
lumbosacral, lesions of (abs), 492; (abs), 493
pair of uniovular twins with symmetrical deformity of (abs), 488
roentgen analysis of (abs), 986
roentgen diagnosis of osteomyelitis of vertebrae, 52
simplification of roentgenography of, 969
unusual locations of tuberculous lesions in (abs), 490
Spleen, miliary calcifications in (abs), 847
Spondyloschisis, roentgen diagnosis (abs), 466
Sterilization of radium and mesothorium needles for surgical purposes (abs), 159
Stevens, Rollin H., honored, 298
Stomach and pleura, fistula between (abs), 843
cancer, treatment (abs), 667
carcinoma, clinical features of (abs), 844
diagnosis of syphilis vs. carcinoma of stomach by thorium dioxide injection (abs), 844
effect of fat introduced into jejunum by fistula on motility and emptying time of (abs), 672
non-carcinomatous tumors of (abs), 487
sarcoma (abs), 487
ulcer, healing of, with persistence of niche roentgenographically, 592
Submentovertex view as aid in mastoid roentgenography, 59
Sugar, influence of injection of, and insulin, on roentgen therapy of malignant tumors (abs), 158
Sulcus, superior pulmonary, intrathoracic sympathoblastoma producing symptomatology of tumor of (abs), 840
superior, tumor of (abs), 839
Sympathectomy, roentgen studies of megacolon treated by, 228
Sympathetic system, effect of roentgen irradiation of, on functional disturbances caused by trauma (abs), 320
Sympathoblastoma, intrathoracic, producing symptomatology of superior pulmonary sulcus tumor (Pancoast) (abs), 840
Symphysis of pubic bones (abs), 494
Syphilis of lungs (abs), 486
of stomach, differentiation from carcinoma by thorium dioxide injection (abs), 844
studies in cardiovascular (abs), 840

Tarsal scaphoid, Köhler's disease of (abs), 978
Technique in diagnostic roentgenology, suggestions for simplifying, 967
of radium treatment of carcinoma of rectum (abs), 155
Teeth of rats, diffraction studies of effect of sodium fluoride and parathormone on, 103
Teleradium therapy (abs), 664
Teleroentgenography in diagnosis of early syphilitic aortitis (abs), 840
of spine (abs), 986
Teratoma of testis, treatment (abs), 668
Testis, teratoma, treatment (abs), 668
Tetanus, spinal deformity following, and its relation to juvenile kyphosis (abs), 491
Tetraiodophenolphthalein, magnesium salt of, in oral cholecystography, 373

THIMBLE CHAMBER measurements, possible sources of error in, 799
THORIUM DIOXIDE, demonstration of ruptured popliteal aneurysm by arteriography with (abs), 660
differentiation between syphilis or carcinoma of stomach by injection of (abs), 844
mastitis following use of (abs), 839
stabilized, hepatosplenography with (abs), 487
THOROTRAST, arteriography by, in study of acquired arteriovenous fistula (abs), 313
hepatosplenography, diagnosis of solitary liver abscess by (abs), 847
myelography with, and subsequent removal by forced drainage, 727
roentgen visualization and diagnosis of breast lesions by means of, 321
THYMUS, effect of atrophy of, following roentgen irradiation, 263
enlarged, incidence of, following prenatal use of iodized salt, 908
some studies of its physiology (abs), 463
THYROID, cancer of (abs), 983
cancer of, in children (abs), 669
effect of irradiation of, on ovarian function (abs), 157
irradiation of, experimental study in radiosensitivity of (abs), 986
THYROTOXICOSES, weak radium therapy of (abs), 664
TIBIA VARA (abs), 978
TIBIAE of rats, diffraction studies of effect of sodium fluoride and parathormone on, 103
TISSUES, susceptibility of, to roentgen rays (abs), 985
TOMOGRAPHIC method, simple and inexpensive, 956
TONGUE, cancer, radium treatment (abs), 666
TONSIL, malignant tumor, radiation treatment (abs), 667
TRAPEZIUM, traumatic axial rotation by gear movement of, and carpal scaphoid, 945
TRAUMA, effect of roentgen irradiation of sympathetic and suprarenals on functional disturbances caused by (abs), 320
TUBERCULOSIS and anthracosilocosis (abs), 150
intestinal, pneumoperitoneum in (abs), 305
of joints, roentgenography of (abs), 979
of spine, unusual locations of lesions of (abs), 490
primary (abs), 148
pulmonary, bilateral artificial pneumothorax in treatment of (abs), 150
pulmonary, bilateral simultaneous artificial pneumothorax in treatment of (abs), 151
pulmonary, circular lesion of (abs), 486
pulmonary, coincident with bronchiectasis in children (abs), 842
pulmonary, of lower lobe (abs), 148
pulmonary, process of resolution in (abs), 148
pulmonary, roentgenoscopic localization of lesions of, for best roentgenographic reproduction, 368
TUMOR, of superior pulmonary sulcus, intrathoracic sympathoblastoma producing symptomatology of (abs), 840
of superior sulcus (abs), 839
TUMORS, adrenal, differential diagnosis (abs), 469
adrenal, perirenal air injection for demonstration of (abs), 469
benign giant cell, treatment (abs), 156
bone, difficulties in diagnosis (abs), 307
bone, of extremities, differential diagnosis by arteriography (abs), 982
bone, roentgen therapy (abs), 316
cartilaginous, unusual of skeleton (abs), 496
cortical, of kidney, immediate effect of radiation in (abs), 984
involving duodenum (abs), 488
malignant, influence of sugar and insulin injection on roentgen therapy of (abs), 158
malignant, of antrum, treatment (abs), 667
malignant, of ovary, treatment (abs), 668
malignant, of pharynx and larynx, present standpoint in treatment of (abs), 669
malignant, of tonsil, radiation treatment (abs), 667
malignant, of vulva, treatment (abs), 668
malignant, surgical and radiation treatment (abs), 664
method of spacing radiation in treatment of (abs), 314
non-carcinomatous, of stomach (abs), 487
of brain, ventricular changes caused by proved, 523
of breast, roentgen diagnosis (abs), 467
of kidney, pyelography in (abs), 848
parathyroid, diagnosis and treatment (abs), 464
primary malignant, of ovary (abs), 315
substitution of air for lipiodol in roentgen visualization of, in spinal canal, 187
tar, in mice, influence of some lead preparations on (abs), 986
TWINS, pair of uniovular, with symmetrical deformity of spinal column (abs), 488

ULCER, gastric, healing of, with persistence of niche roentgenographically, 592
of rectosigmoid following roentgen and radium treatment of carcinoma of cervix, 879
of rectum following roentgen and radium treatment of carcinoma of cervix, 878
ULCERATION of small intestine following irradiation of pelvis, 895
UNDULANT FEVER, pulmonary changes in (E), 459
UNITS, radiological recommendations of International Committee for, 295
URETER, importance of roentgen study of (abs), 468
UROGRAPHY in tumors of kidney (abs), 848
intravenous and subcutaneous, comparative study (abs), 848
UROLOGICAL diseases in female, roentgen diagnosis (abs), 306

Uterus, adenocarcinoma of body of, successful radiotherapy (abs), 154
calcified fibromyoma of, simulating large vesical calculus (abs), 848
cancer of body of, roentgen therapy (abs), 154
carcinoma, combination of radiotherapy and chemotherapy in (abs), 662
carcinoma, irradiation in treatment of, 855
cervix, cancer, correlation of calculated tumor doses and five-year survivals in radiation therapy of, 861
cervix, carcinoma, intestinal injuries after radium and roentgen treatment of, 871
cervix, carcinoma, methods of applying radium element to, 819
cervix, carcinoma, treatment (abs), 668
cervix, proctitis following radium therapy of (abs), 662
fundus, cancer, treatment (abs), 668
fundus, carcinoma, changing phases in treatment of (abs), 468
myoma, relation of presenting symptoms to selection of method of treatment in, 849

Vagina, cancer, methods of applying radium element to, 820
Vaginitis, gonorrheal, use of estrin in, 91
Venoms, African snake, clinical experiments on effect of, on human cancer, with or without deep therapy (abs), 986
Ventricles, systematic method of examining, 524
Ventricular changes caused by proved tumors of brain, 523
Ventriculography (abs), 839
Vertebrae, metastatic carcinoma of, symptomatology and therapy of (abs), 670
roentgen diagnosis of osteomyelitis of, 52
significance of lumbosacral transitional (abs), 308
spinal, injuries to accessory processes of (abs), 490
Vertebral arch, isolated fractures of, 43
Volvulus of sigmoid megacolon, roentgen diagnosis, 925
Vulva, malignant tumors, treatment (abs), 668

Wave length, dependence of roentgen-ray erythema on (abs), 986
Werner, Wilbur S., 1895–1937, obituary (E), 291
portrait, 291
Wheat seedlings, experiments on, with neutrons and roentgen rays, 613
Withers, Sanford Martin, 1891–1938, obituary (E), 823
portrait, 823

Xanthoma tuberosum in childhood due to infectious cirrhosis of liver (abs), 980

AUTHOR INDEX TO VOLUME 39

Adair, Frank E., 421
Adams, Carroll O., 489
Adams, Herbert D., 984
Adams, William E., 312
Adams, Z. B., 490
Aird, Robert B., 158
Alexander, Gilbert H., 956
Alexander, John, 472
Allen, Lewis G., 67
Alldredge, Rufus H., 975
Amberson, J. Burns, Jr., 148
Anderson, Wm. D., 489
Andrews, J. Robert, 985
Arens, Robert A., 845

Babey, A., 840
Bachman, Arnold, 202
Bakwin, Harry, 981
Ball, Clarence F., 891
Barclay, A. E., 129, 381, 673
Barden, Robert P., 466
Barr, Joseph S., 492
Barringer, Benjamin S., 82
Barth, Earl E., 534
Bauer, Walter, 980
Baum, Felix, 486
Baumann-Schenker, Rudolf, 155
Beal, Arline M., 210
Begg, R. Campbell, 306
Bell, Dorothy, 387
Bell, Joseph C., 916, 924
Bellot, A., 300
Bennett, G. A., 980
Berg, H. H., 844
Bergstrand, Hilding, 982
Berman, Maxwell D., 983
Berman, Theodore M., 847
Best, R. Russell, 321
Beutel, A., 843
Binger, Melvin W., 665
Birge, Richard F., 840
Birkelo, C. C., 486
Blady, John V., 205
Bloom, N., 980
Blount, W. P., 978
Boerner, Fred, 235, 601
Bollman, V. L., 985
Bond, Russell C., 319
Bordet, Emile, 473
Bowers, Ralph F., 975
Bowing, H. H., 155
Bradshaw, Howard H., 465
Brams, W. A., 840
Broders, Albert C., 314
Brodney, M. L., 306
Bruckheimer, Ralph M., 151
Brust, John C. M., 662
Bugbee, Edwin P., 655
Burgener, A., 848
Burman, Michael S., 945
Burnam, Curtis F., 75, 83
Buschke, Franz, 312

Cadden, A. V., 151, 152
Caldwell, Chas. W., Jr., 834
Camp, John D., 975
Cantril, S. T., 312
Carman, H. Frank, 150
Carter, Ray A., 487
Case, James T., 923
Cassen, Benedict, 634
Cathie, I. A. B., 895
Cavanagh, John R., 847
Chamberlin, George W., 470
Chaoul, H., 318
Cherry, Homer H., 368
Chor, Herman, 534
Chown, B., 981
Christie, Arthur C., 161
Chuinard, Eldon G., 312
Clark, George L., 672
Clarkson, Wright, 260
Cleaves, Edwin N., 964
Clerf, Louis, H., 466, 842
Clovis, Charles H., 319
Cochems, K. D., 840
Compere, Clinton L., 312
Compere, Edward L., 312
Corrigan, Kenneth E., 103, 286, 634
Corscaden, James A., 871, 893
Corsello, Joseph N., 151
Cosman, Bernard J., 972
Coutard, H., 663
Cowett, Max P., 64
Crabtree, F. Granville, 306
Cramer, W., 662
Crane, A. W., 450
Craver, Lloyd F., 205
Crawford, Robert R., 659
Crocker, Charles, 475
Cutler, Max, 312

Dapsy, Andreas, 155
David, David M., 468
Decker, Fred H., 747
Decker, John J., 490
Degrais, P., 300
Dempster, James H., 832
des Ligneris, M., 986
Desjardins, A. U., 290, 747
Desplats, R., 320
Deutschberger, O., 670
Dicky, Lloyd B., 842
Dietel, F. G., 320
Dillehunt, Richard B., 312
Dirkse, Paul R., 841
Dittrich, R. J., 937
Doig, A. T., 485
Donaldson, Blake F., 202
Donaldson, S. W., 908
Dooley, Emmett A., 834
Douglas, Edward, 487
Dowell, D. A., 318
Dowell, D. H., 843
Dresser, Richard, 972
Duffy, James J., 767
Dyes, Otto, 652

Ebenius, Bertil, 651
Eckert, Clarence T., 986
Egbert, Dan S., 150
Ehrenfeld, Irving, 64
Eichenlaub, F. J., 596
Engelbreth-Holm, J., 159
Ericksen, Lester G., 731
Ewing, James, 165

Fang, H. C., 311
Fariñas, P. L., 982
Farrow, J. H., 799
Fawcitt, Richard, 19, 650
Fels, S. S., 263, 463
Ferguson, Albert B., 979
Finzi, N. S., 144, 261
Firor, Whitmer B., 651
Fischel, Eugenio, 485
Fischgold, H., 473
Fleischner, F., 842
Fleming, Bruce L., 659
Francisco, C. B., 496
Frank, R., 671
Franklin, K. J., 673
Fray, Walter W., 899
Frazell, E. L., 861
Freedman, Eugene, 720
Freund, Ernst, 216, 496, 660
Fricke, Robert E., 155
Friedman, Asa B., 985
Friedman, Harry F., 984
Friedman, Lewis J., 548
Friedman, Milton, 892
Friedman, Paul S., 548
Frost, Thomas T., 840
Füssl, E., 984
Furlow, Leonard T., 485

Galinson, Sim, 986
Garland, L. H., 713
Geiger, Arthur J., 150
Gericke, W., 159
Gerli, Pietro, 486
Gershon-Cohen, J., 263, 463
Gerundo, Michele, 496
Geschickter, Charles F., 90, 844
Gibert, P., 154
Gilbert, Philip D., 467
Gilliard, Andre, 661
Gitlow, Samuel, 841
Glass, George A., 834
Glenn, Frank, 487
Glickman, L. Grant, 151
Goldberger, Jacques, 475
Golden, J. S., 840
Goldfeder, Anna, 84
Good, Frederick L., 985
Gordon, Arnold M., 844

Gordon, Burgess L., 464
Gould, S. E., 741
Grace, Edwin J., 159
Grasset, E., 986
Green, William T., 495
Greenblatt, Robert B., 847
Greenhill, J. P., 488
Grethmann, Wolfgang, 149
Grinker, Roy R., 299
Gross, M. J., 278
Gross, Robert E., 344
Gunn, Francis D., 311

Haden, Russell L., 259
Haffner, Johan, 488
Hall, M. R., 925
Hall, Wendell C., 393
Hamilton, Joseph G., 487
Hansen, K., 845
Hare, H. F., 669
Hargrave, Robert L., 314
Harris, R. I., 307
Harris, T. T., 321
Harrison, Edward K., 846
Hasney, Fred A., 486
Hauser, Harry, 720, 982
Havlasek, Ludvik, 662
Hayden, Henrietta S., 103, 286, 634
Healy, William P., 887
Heckel, Norris J., 377
Heise, Fred H., 149
Henderson, Samuel G., 235, 601
Hennell, Herman, 841
Hicken, N. Frederick, 321
Higley, Charles S., 720
Hill, Harold A., 846
Hirsch, I. Seth, 658
Hodes, Philip J., 397
Hodges, Fred M., 578
Hosford, John P., 308
Hudson, J. Cramer, 986
Humphris, F. Howard, 300
Hunscher, Helen A., 103
Hunt, Howard B., 321
Hunter, Francis T., 319
Hussey, Hugh H., 487
Huyler, W. C., 967
Hynes, John F., 407, 426

Impink, Robert R., 467
Inouye, Kazuo, 158
Izzo, Roque, A., 473

Jaches, Leopold, 131
Jacobs, J. Bay, 848
Jacox, Harold W., 778
Janker, Robert, 145
Jegorow, Boris, 315
Joannides, Minas, 152
Johnson, J. B., 95
Joliffe, Norman, 64
Jordan, H., 986
Joress, Mark H., 148
Jupe, M. H., 839
Jutras, Albert, 792

Kaplan, Ira I., 84, 387, 651
Karp, Meier G., 978
Kasabach, Haig H., 871
Kasman, Louis P., 488
Kasper, J. A., 486
Kegerreis, Roy, 658
Kelly, James F., 318, 843
Kemp, J. E., 840
Kieffer, Jean, 497
Kirklin, B. R., 1, 142, 144, 292
Kling, David H., 495
Knierer, W., 982
Kolju, K. J., 928
Kontoff, H. A., 306
Kornblum, Karl, 235, 260, 601
Koster, Harry, 488
Koucky, Rudolph, 353
Krida, Arthur, 981
Kruchen, C., 317

Laing, Donald R., 487
Lampe, Isadore, 613
Lang, Gustav, 159
Lawrence, W. S., 489
Leddy, Eugene T., 747, 984
Lee, Margaret, 981
Lee, Walter E., 467
Lenz, Maurice, 871, 891
Leunig, H., 159
Levin, Isaac, 427
Levine, Samuel, 470
Lewin, Hans, 159
Liberatore, Theodore, 483
Liberson, Frank, 978
Lilienthal, Howard, 564
Lipschultz, Oscar, 489
Loebell, M. A., 274
Logròscino, Domenico, 308
Lonergan, Robert C., 311
Love, J. Grafton, 975
Lowenburg, Harry, Sr., 981
Lütteken, W., 317
Lukens, Francis D. W., 469
Lynham, J. E. A., 153
Lysholm, Erik, 651

Macbeth, R. G., 673
McClure, Roy D., 660
McCord, William M., 660
McCordock, Howard A., 486
McFarland, Joseph, 467
McIndoe, R. B., 151, 152
McKay, Donald R., 843
McLaughlin, A. I. G., 485
McNeill, Clyde, 959
McNutt, John R., 52
McPhedran, F. Maurice, 148
Macy, Icie G., 103
Maier, E., 664
Maier, Herbert C., 687
Maner, George D., 660
Marinelli, L. D., 799
Marshak, A., 985
Martin, Charles L., 847, 891
Maskin, M., 672
Maxwell, James, 149
Mayer, Edgar, 149
Maytum, Charles K., 984
Melchart, Franz, 152
Menees, T. O., 373
Menne, Frank R., 840
Mensor, Merrill C., 490
Meranze, D., 263
Meranze, David R., 471
Meranze, T., 263, 471
Meservey, A. B., 439
Mesirow, Sidney D., 845
Meyer, Karl A., 305
Meyer, William H., 665
Meyerding, Henry W., 156, 314, 316
Middleton, E. L., 149, 150
Middleton, William S., 975
Milch, Henry, 977
Miltner, Leo J., 311
Minnes, James F., 844
Mitchell, C. Leslie, 659
Mitchell, G. A. G., 308
Momigliano, Emanuele, 157
Moore, Sherwood, 486, 514
Mortensen, O. A., 727
Morton, J., 314
Morton, S. A., 489
Moschcowitz, Eli, 839
Mottram, J. C., 314
Muellner, S. R., 306
Mulinos, Michael G., 671
Muller, George P., 465
Murphy, John T., 568
Murphy, Walter T., 315
Mutscheller, Arthur, 665

Necheles, H., 671, 672
Neely, J. Marshall, 488
Newcomet, William S., 470
Neymann, Clarence A., 653
Nicholson, William P., 983
Nichel, A. C., 271
Niedermayr, R., 670
Nosik, W. A., 727

O'Brien, Frederick W., 668
Ostrum, Herman W., 465
Otell, Lawrence S., 487

Pack, George T., 666
Page, Irvine H., 160, 476
Palmer, Dorwin L., 650
Palmieri, G. G., 664
Pancoast, Henry K., 169
Paul, L. W., 846
Peacock, Alexander H., 848

Peirce, Carleton B., 841
Pendergrass, Eugene P., 397, 426
Pepper, O. H. Perry, 464
Pfahler, George E., 1, 422, 466, 892
Phaneuf, Louis E., 855, 893
Pich, Gertraude, 494
Pillai, M. J. S., 379
Pohle, Ernst A., 831, 975
Pollock, William C., 149
Pomeroy, Lawrence A., 590
Popović, L., 669
Popp, Walter C., 665
Poppel, M. H., 592
Porter, John L., 311
Prather, Geo. C., 984
Probst, V., 320
Probstein, J. G., 986
Pusitz, M. E., 496

Quimby, Edith H., 799

Radasch, H. E., 659
Raiford, F. T., 741
Raiford, Theodore S., 671
Rasetti, Franco, 145
Ravdin, I. S., 464
Rechtman, A. M., 494
Reeves, Robert J., 846
Regen, Eugene M., 157
Rehbock, Donald J., 982
Reimann, Stanley P., 467
Reisner, David, 148
Reynolds, Lawrence, 103, 286
Rhoads, J. E., 464
Rhodes, Robert L., 847
Richman, Samuel, 985
Rigler, Leo G., 353
Ritchie, Gorton, 975
Roberg, O. Theodore, Jr., 491
Robinson, H. C., 373
Robinson, J. Maurice, 319
Roesler, Hugo, 469
Rosendale, Raymond S., 843
Rosenthal, Maurice, 159
Rosi, Peter A., 305
Ross, J. Cosbie, 152
Rothman, Maurice M., 471
Rowe, Edward W., 488
Rudolph, J. A., 477
Ruggiero, A., 848
Rutledge, C. P., 846

Sahlstedt, Hans, 651
Salkin, David, 151, 152, 305, 363
Samuel, E. C., 924
Sandler, I. Lewis, 596
Sante, L. R., 473
Sashin, David, 491
Schambye, Grethe, 318
Scheffey, Lewis C., 468
Schenck, Samuel George, 585, 980
Schenk, Harry P., 465
Schillinger, Raphael, 193
Schindler, Rudolf, 984
Schlomovitz, Benjamin H., 151
Schloss, W., 152, 665
Schmier, Adolph A., 945
Schmitz, Henry, 425, 849, 892
Schneider, Georg H., 670
Schönbauer, L., 664
Schreiner, B. F., 890
Schroeder, Carl, 661
Schulteg, 317
Schulze, Fritz J., 523
Schwartz, Charles Wadsworth, 32, 698
Schwarz, Gottwald, 475
Scott, Michael, 187
Scott, Walter, 309
Scott, Wendell G., 486
Scott-Brown, W. G., 315
Seeds, Asa E., 485
Seemann, Herman E., 628
Seligman, Bernard, 985
Selinsky, Herman, 985
Selle, W. A., 95
Senger, Fedor L., 848
Settle, Francis B., 983
Shannon, James G., 495
Shapiro, Louis L., 64
Shay, Harry, 263, 463
Shebesta, E. M., 839
Sheinfeld, William, 488
Shenk, John H., 672
Shields, William P., 981
Simmons, Channing C., 984
Simonsen, M., 845
Skinner, Edward H., 826
Sloane, David, 495
Sloane, Marian F., 495
Smith, Frank R., 866, 893
Smith, H. Brooks, 271
Snure, Henry, 660
Sokoloff, Martin J., 150
Solis-Cohen, Leon, 463, 470
Solomon, L., 154
Sommer, George N. J., Jr., 666
Sowers, B. F., 839
Spackman, James G., 407
Spencer, Jack, 319
Stafford, Frank B., 151
Stark, Jesse Donald, 480
Stead, G., 129
Stecher, William Robert, 303
Steidl, John, 149
Stein, Irving F., 843
Steinbach, Meyer, 463
Steiner, Georg, 43
Stern, Walter G., 310
Stokes, Joseph, Jr., 980
Stone, Robert S., 487, 523
Strauss, A. A., 672
Strauss, S., 672
Sturtevant, Mills, 64
Sullivan, Maurice, 483
Sutro, Charles J., 494

Taft, E., 672
Taylor, Grantley W., 153, 419, 984
Todd, T. Wingate, 831
Towsley, H. A., 908
Travers, J. Townsend, 839
Treves, Norman, 424, 783
Tuggle, Allan, 488
Turner, Henry, 310
Turnoff, David, 981
Tutunjian, Khacher H., 658

Uhle, Charles A., 985
Uhlmann, E., 318, 663
Unger, Arthur S., 592

Valach, L., 665
Van Buskirk, E. M., 228
Vaughan, Walter W., 344
Veal, J. Ross, 660
von Pannewitz, G., 845

Walker, Harry, 980
Wallace, Robert P., 64
Wangensteen, Owen H., 476
Warren, Shields, 666
Wasch, Milton G., 585
Wasserburger, K., 664
Waters, Charles A., 651
Watson, William L., 153
Waugh, John M., 672
Weber, Harry M., 923
Weidman, Fred D., 980
Weintraub, Sydney, 488
Wessely, E., 669
Westing, Siegfried W., 59
Westra, J. J., 95
Weysser, C., 669
Widmann, Bernard P., 469
Wilkins, George C., 816
Wilkins, Walter E., 157
Williams, Leonard, 300
Williams, Paul C., 492, 493
Williams, Thomas, 659
Wilson, Angus K., 888
Wintz, Hermann, 154
Wintherspoon, J. Thornwell, 670
Wolpaw, Sidney E., 840
Woodhall, Barnes, 485
Woodhouse, D. L., 986
Wruble, Milton 450
Wucherpfenning, V., 665
Wulff, Helge B., 299

Yater, Wallace M., 313, 487, 660, 847
Young, Barton R., 187

Zavod, William A., 150
Zimmerman, L. M., 671
Zirkle, Raymond E., 613

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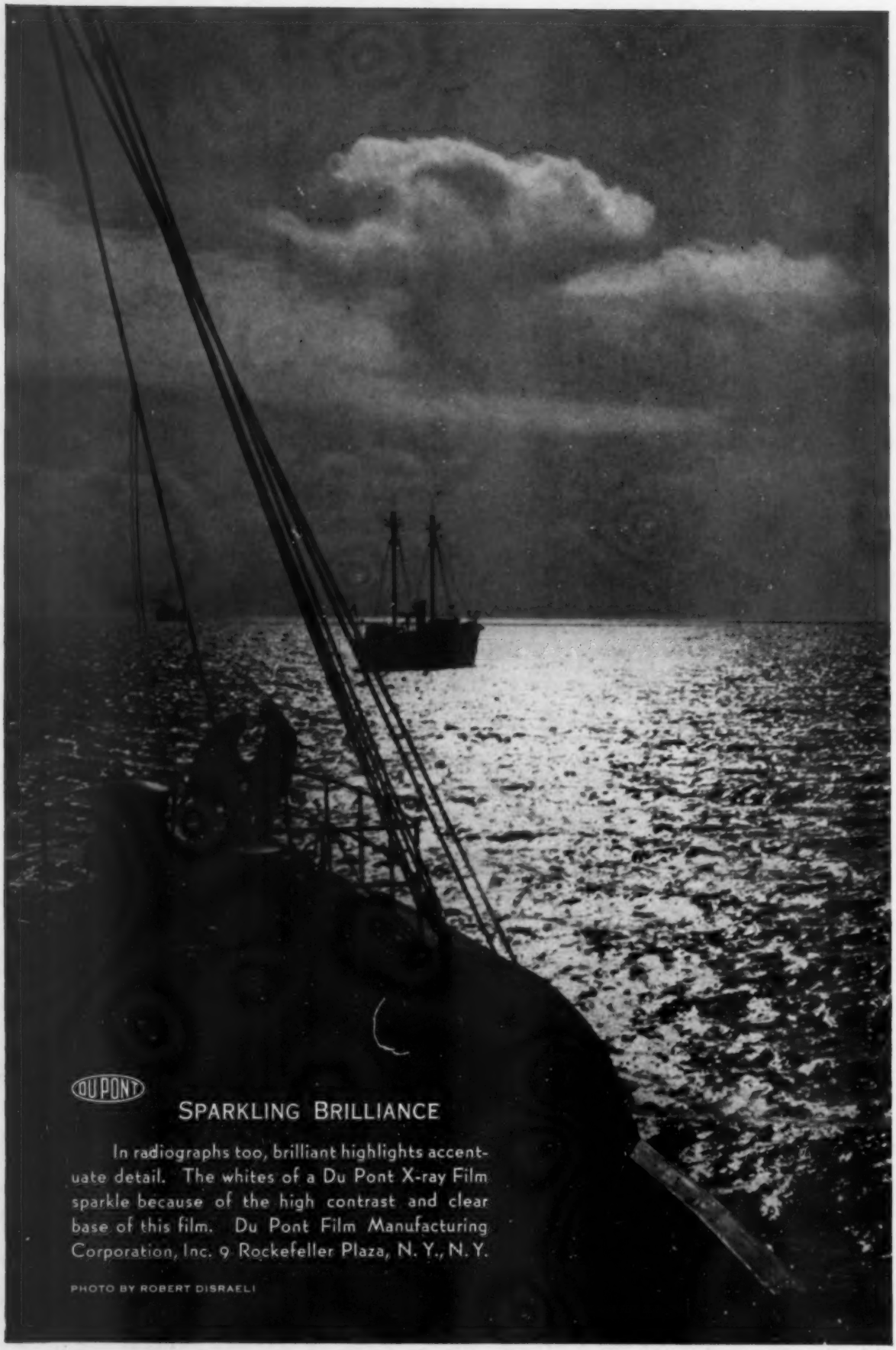
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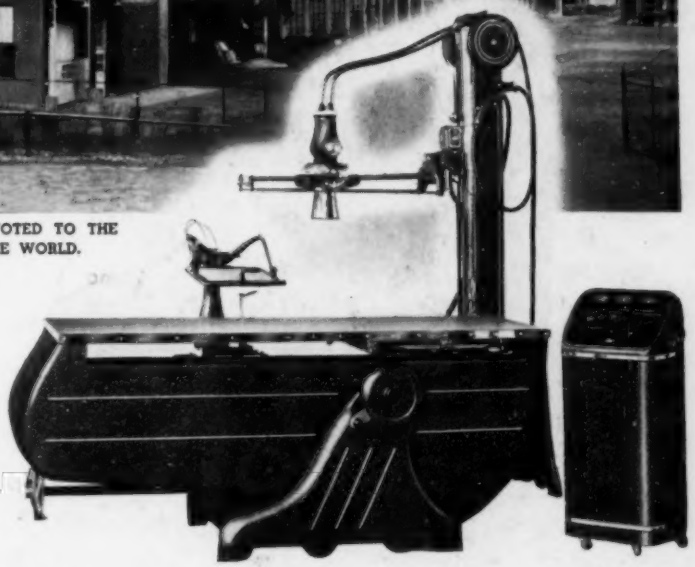

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